THE LONDON NATURALIST

the journal of the
LONDON NATURAL HISTORY SOCIETY

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LONDON NATURAL HISTORY SOCIETY

The Society welcomes new members, both beginners and experts. Its Area lies within a 20-mile (32 km) radius of St Paul's Cathedral and here most of its activities take place. Although much is covered with bricks and mortar, it is an exciting region with an astonishing variety of flora and fauna. The Society comprises sections whose meetings are open to all members without formality. For those interested in arachnology, archaeology, botany, conchology, conservation, ecology, entomology, geology, herpetology, mammalogy, ornithology or rambling there is a section ready to help.

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THE LONDON NATURALIST

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Charles de Worms

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Contents

Report of the Society for 1979*

The Society is still trying to consolidate itself after the losses of key personnel last year and the subsequent losses this year. The workload is falling on the shoulders of those who are already busy. There is a great need for more help and more ideas—especially from younger people.

Three resignations deserve mention: That of Jack Laundon who has edited *The London Naturalist* for nine years with great competence; Mrs Pearl Small, who has retired as Chairman of the London Nature Conservation Committee and has been the backbone of this active and valuable group since its inception (Fortunately, we are not to lose her totally, as she has been elected as Adviser to the LNCC); and Mrs Barbara Barrett, who has been Membership Secretary for thirteen years. Their service to the Society has been tremendous, and they earn our deep gratitude.

The research work done by the Society's members and groups continues to be recorded in our various publications, which remain our permanent contribution to science. We thank all those who help compile the publications and also Ray Softly's team of volunteers who distribute them. The membership has also enjoyed a full and varied programme of one or more field trips every weekend and almost weekly lectures by experts both professional and amateur.

Inflation has at last made its mark, and we have felt obliged to increase the subscriptions by 50% to meet rising costs necessary to maintain the standards required of the Society. This is the first increase in four years, and hopefully, it will stem the tide for a short while at least, and we hope the membership will be understanding and remain loyal.

Membership numbers are slightly down from last year, but show no dramatic trends, although the drop in Junior Membership may reflect the need to attract more young people into the Society and educate them to the pleasures of natural history.

	1979	*1978*
Ordinary	1,017	*1,019*
Affiliated	20	*20*
Family	101	*106*
Junior	59	*65*
Senior	48	*45*
Honorary	14	*14*
Life	11	*13*
Total	1,270	*1,282*

We learn, with regret, of the following deaths during the year: Dr J. M. H. Campbell, P. E. Carter, Baron C. G. M. de Worms, A. E. F. Hammond, Mrs J. Page, R. J. Progin and R. H. Macdonald.

As always, we thank Imperial College for allowing us to use their rooms for committee meetings, and Mr Whitworth and his staff for the custody of the Society's library. Finally, we thank all those who have done so much during the year to keep the Society and its work at such a high level.

* Presented at the Annual General Meeting, 8 December 1979.

Two Thames Foreshore Deposits in West London

by E. A. and J. B. E. JARZEMBOWSKI*

The Thames foreshore is usually covered by surface sediment and detritus in the bend of the river traversed by Hammersmith Bridge. However this cover is broken at several points to reveal London Clay overlain by old Thames Alluvium. Exposures vary depending on the state of the river and distribution of surface sediment. The old river alluvium includes several different deposits and here we submit dates for two of them. The material collected was all found within the deposits except where otherwise indicated. A representative sample of the material collected is to be deposited in Gunnersbury Park Museum.

1. Chiswick Eyot

Simons (1964) described and discussed the age of deposits on the S.E. side of this elongate island in the Thames. The strata there consist of shelly sands capped by 'four to five feet of Recent, grey river clay.' The sands were considered to be of Roman or Medieval age but the paucity of artefacts made dating uncertain. Our observations show that objects dating from the seventeenth century onwards are common on the foreshore in this area but earlier material is comparatively rare.

The N.W. side is considered here where the grey clay is considerably thicker and seen in a face up to some 4m high now being cut back by the river. It is only exposed at low tide when it is fronted by a pool up to 0.5m deep, and the water level was used as a datum horizon. The clay is soft and accessible only in the lower part; it is sometimes seen to extend below datum but there is no trace of the sandy units developed on the S.E. side. The clay is bedded and brittle *Unio* valves as well as the more robust shells of *Viviparus viviparus* L. and *Ostrea edulis* L. occur sporadically. Mammalian bones, flint pebbles and ceramic objects occur occasionally, the last providing dates as follows:

(i) a group of five similar pipes of type 9 (Oswald, 1975) c. 1680 – 1710. 0.25m above datum. Grid reference TQ 21897800. The pipes were lying horizontally in close proximity, and although the stems were incomplete as usual, there were no associated stem fragments. This and the fact that the pipes were aligned suggest contemporary current activity. The unworn surfaces of the pipes indicate that the activity was of a limited nature.

(ii) a single pipe of type 21 (Atkinson & Oswald, 1969) c. 1680 – 1710. Less than 1m above datum. TQ 219780.

(iii) an unworn piece of salt-glazed stoneware, coloured grey and cobalt blue with flower reliefs, and a piece of delftware. 0.5 and 0.3m above datum respectively. TQ 21847795.

Sample (iii) is consistent with the dates indicated by (i) and (ii) for the basal part of the succession above datum. Fresh pipes dating to about 1660 – 1680 are sometimes found loose on the S.E. side of the pool and suggest that the clay below datum dates to the reign of Charles II.

We have observed pipes in the lower part of the grey clay and top few centimetres of sand on the S.E. side of the island. They range from about 1670 – 1790 but the material is stratigraphically mixed and has been reworked.

*94 Carthew Road, London, W.6.

2. Foreshore below Riverview Gardens, S.W.13.

A band of orange sand with *Unio* is sometimes seen in the lower part of the foreshore 120m S. of Hammersmith Bridge (TQ 230779). It extends for about 15m and is up to 25cm thick. The shells are often paired with periostracum and ligament preserved but they are extremely brittle. *Unio tumidus* Philipsson has been identified and bleached shells of *Viviparus viviparus* L. are also common; occasional valves of oyster, winkle and whelk probably represent human refuse. The sand also contains mammalian bones, flint pebbles and fragmentary artefacts (mainly ceramic). The last were collected carefully as the area is sometimes searched with metal detectors and the narrow holes dug by the operators might introduce foreign matter. Objects from the sand are frequently encrusted with calcareous tufa and the lithology is very similar to the sandy deposits on Chiswick Eyot (Simons, 1964) although dated artefacts indicate a younger age:

(i) Upper part of wine bottle, unabraded and corked; end of seventeenth century or beginning of eighteenth. (Very similar to more complete examples in Wills, 1968, fig. 14).

(ii) Base of a wine bottle, late eighteenth century (*cf.* Noël Hume, 1974, fig. 13 – 1788 right). An unworn and corked bottle neck dating to the second half of the same century was found loose in this area (ibid. fig. 12 – 1761 left).

(iii) 3 pipes type 10 (Oswald, 1975) c. 1700 – 1740. An unworn stem, 19cm long, was found with the thin mouth region intact.

(iv) 1 pipe type 27 (Atkinson & Oswald, 1969) spur without mould line c. 1780 – 1800.

(v) 1 pipe unworn, very similar to Oswald (1975, pl. 6, fig. 11) but writing indecipherable. Early nineteenth century.

The artefacts span a period of time in excess of 100 years, the youngest indicating that deposition occurred as late as the first half of the nineteenth century; however the unworn nature of some of the older objects suggests that some deposition also occurred in the eighteenth century. Other artefacts from this deposit have yet to be studied in detail, but preliminary observations are consistent with this dating.

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The Flora of Southern Epping Forest Part 1: Wanstead Park

by P. R. Ferris*

Summary

A survey of the flora of Wanstead Park in southern Epping Forest was carried out during the years 1975 to 1979. A total of 260 species of vascular plants was found to occur in this heavily used park in the suburbs of east London. The park and its various habitats are described and the species listed.

Introduction

Epping Forest is an historic woodland lying in the west of the county of Essex on the ridge of high ground which separates the Lea Valley on the west from the Roding Valley on the east, and which extends southwards into what are now the London Boroughs of Redbridge, Newham and Waltham Forest. Since 1975, members of the Wren Conservation Group have gathered records of the flora of an area at the southern end of Epping Forest, Wanstead Park. In 1976 the area of study was extended to include Wanstead Flats and Bush Wood, and a system of record cards was established. In 1978 the area was further extended northwards to include Leyton Flats, Snaresbrook and Gilbert Slade, as far as the Waterworks Corner roundabout on the North Circular Road (Fig. 1), and at the present time the Wren Conservation Group has a commitment to biological recording in Epping Forest south of this point on behalf of the Epping Forest Conservation Centre. Since the local biological records centre for the west of Essex is at the Passmore Edwards Museum in Stratford, London E.15, records are also filed here.

For the purpose of biological recording, the Epping Forest Conservation Centre divides the forest into 38 areas, of which the four most southerly comprise the area of study of the Wren Conservation Group. Because of the differing characters of the floras of each of these areas this paper is in four parts. Apart from providing an accurate record of the present flora of Wanstead Park, it is also intended to present a readable synopsis of the flora to both experts and beginners alike. For this reason the English and scientific names are given in the text and in the species list.

A map of Wanstead Park is presented in Fig. 2, and it is suggested that this be referred to whilst reading the following description of the park and its flora.

Wanstead Park

Wanstead Park is managed by the Corporation of London as a part of Epping Forest under the terms of the Epping Forest Act, 1878, although for historical reasons the style of management differs from that of the rest of the Forest. Wanstead Park, which was first enclosed about three centuries ago, once formed part of the landscape grounds of a large mansion known as Wanstead House, which stood on what is now Wanstead Golf Course. The complicated history of the park, which included a period of cattle grazing, is summarized by Addison (1973). As an example of the type of amenity area attached to such a 'Great House', the continued enclosure of the Park was felt justified and steps are taken

*Wren Conservation Group, c/o Passmore Edwards Museum, Romford Road, Stratford, London E.15.

Epping Forest at Upper Walthamstow (London Borough of Waltham Forest). Fine remnants of oak-hornbeam woodland remain off Woodford New Road, as this photograph of old *Quercus*, pollarded *Carpinus* and large *Ilex* shows. This issue contains the first of a short series of articles dealing with the rich flora which persists in the southern part of Epping Forest. Photograph: J. R. Laundon, April 1960.

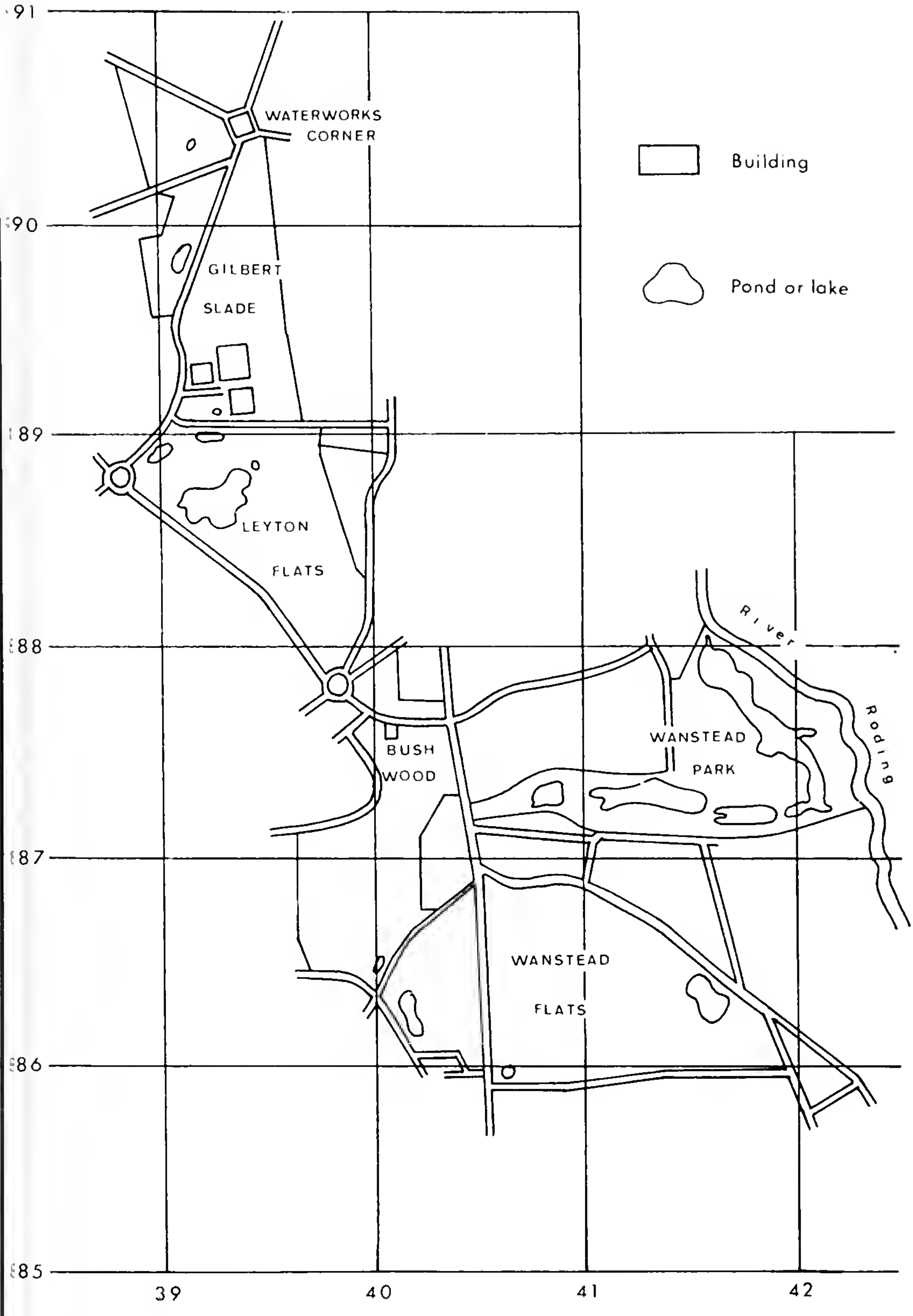

FIG. 1. Southern Epping Forest. The marginal numbers relate to the 1km lines of the National Grid.

to maintain that aspect. These essentially consist of 'keeping nature under control', whereas in the rest of Epping Forest the form of an ancient forest perpetuated by natural regeneration is maintained. The boundaries of Wanstead park proper are clearly defined by a fence with gates which are locked at night.

For the purpose of this survey of the flora of the park the eastern boundary is taken as the River Roding, including the east bank and a small wooded area on it known as Whisker's Island. To the west the survey area includes the parkland surrounding the Heronry Pond outside the enclosure, taking in the Shoulder of Mutton Pond and Reservoir Wood. The total area comprises in the order of 74 hectares.

The park is fortunate in being surrounded by other areas of open space, even though so close to east London. Golf courses provide its nothern neighbours and much of the River Roding's east bank is adjacent to playing fields and a recreation ground. Both are carefully managed and the number of plants in the park that originate from them is probably negligible. However, a part of the river's east bank adjoins allotment gardens, and certainly some of the species to be found in that locality do originate from there. The site of the now disused Redbridge (Southern) Sewage Treatment Works on the south-west boundary is also a cross-over point for plants. Much of the southern boundary of the park is close to houses, the gardens of those in Woodlands Avenue being separated from Reservoir Wood only by a wooden fence. Garden escapes and outcasts have become established here. The higher parts of Wanstead Park are on gravels of the Taplow Terrace and the lowest part in the south-east is on London Clay. The geological boundary is not at all clear and has no direct effect on the flora.

Reservoir Wood

The dominant tree in this area is the English oak *Quercus robur,* with numerous hornbeams *Carpinus betulus;* some splendid mature specimens of both may be found. Only the North Circular Road separates this wood from Bush Wood, whose tree flora is remarkably similar to that of Reservoir Wood. Bush Wood will be discussed in part two of this paper, but it is thought fit to mention at this stage the similarity of the two adjacent woods and also the marked difference between the tree flora of both and that of the other areas of southern Epping Forest. Enchanter's nightshade *Circaea lutetiana* can be found in both Reservoir and Bush Woods and is more plentiful here than elsewhere. Plants recorded here and not elsewhere in the area include the green alkanet *Pentaglottis sempervirens,* which grows at the side of a normally dry ditch, and snowberry *Symphoricarpos rivularis* near the houses. Also here can be seen garden escapes and outcasts such as spotted dead-nettle *Lamium maculatum* and sweet alison *Lobularia maritima.* In the spring several varieties of *Narcissus* and *Crocus* grow at the edge of the wood.

The Lakes

When it is not dry, a stream runs through Reservoir Wood and empties into the Shoulder of Mutton Pond, the first of a chain of four lakes through the Park. This is the Park's smallest lake, being about 1.21 hectares, and takes its name from its shape. For two reasons it is the most open of the four lakes: first it lacks islands, and second very few tall plants grow around its margin. An area of mostly soft rush *Juncus effusus* and great water grass *Glyceria maxima* occurs on the southern edge of this lake; amongst these plants may also be found spike rush *Eleocharis palustris.* Some hard rush *Juncus inflexus,* water mint *Mentha aquatica* and trifid bur-marigold *Bidens tripartita* may also be found at the water's edge, although the gravelly north bank is largely devoid of vegetation apart from various grasses. With the exception of hard rush, which has only been

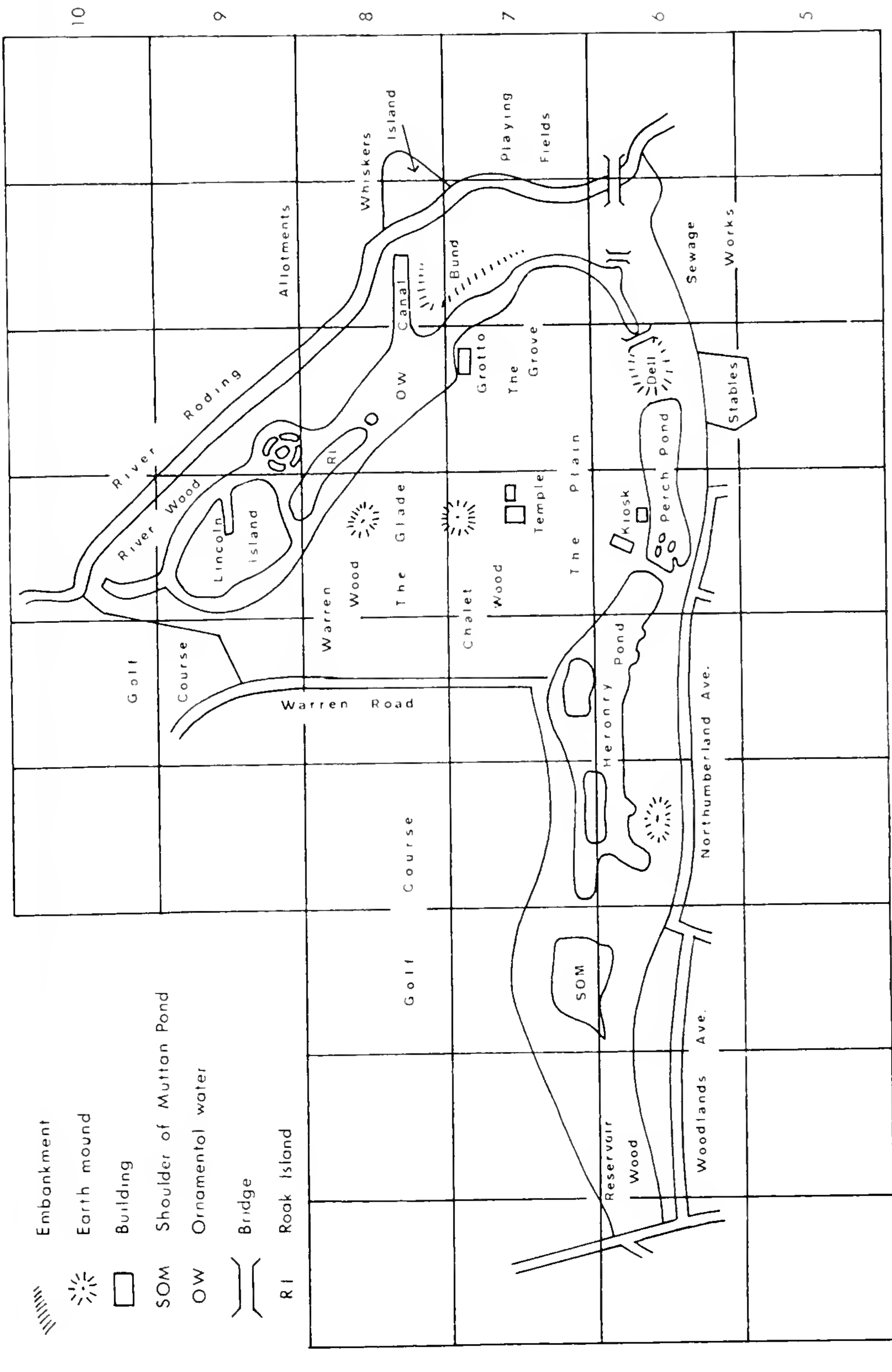

FIG. 2. Wanstead Park, November 1979.

found at this location, and spike rush, which has only been found here and in the Heronry Pond, the other four species just mentioned are to be found around all of the Park's lakes.

The Heronry Pond is the next lake in the chain and with an area of 4.45 hectares is the second largest. It differs from the other lakes in possessing sloping concrete banks all around. The west end is somewhat the narrower and is more closely surrounded by trees and other vegetation. One of this water's two islands is situated at this end, reducing further the width of the water and resulting in a muddy environment as the lake dries out in the summer months. Here may be found floating sweet-grass *Glyceria fluitans* and its hybrid *G. x pedicellata,* although searches for the other parent, *G. plicata,* have proved fruitless. Amphibious bistort *Polygonum amphibium* is particularly common in the Heronry Pond, as is water crowfoot *Ranunculus peltatus,* whose white blossoms. cover much of the lake's surface in early summer. This species has also been found in the Ornamental Water, but not in either the Shoulder of Mutton or Perch Ponds. On the rare occasions when the Heronry Pond is full to capacity overflow water passes directly into the Perch Pond by a pipe. With an area of 2.23 hectares this lake maintains a fairly constant level of water and is used extensively for fishing and also boating. The former activity has resulted in much erosion of the banks and patches of bare earth can be seen at intervals. However, a few small islands at the west end of the lake yield birches *Betula pubescens* and *B. pubescens x pendula* hybrids, alder *Alnus glutinosa* and various willows *Salix* spp. The other vegetation is largely *Glyceria maxima* and yellow flag *Iris pseudacorus.* Most of the Park's alder trees are to be found around this lake, particularly along the northern bank, or in the Dell, through which overflow water passes from the Perch Pond to the Ornamental Water.

The Ornamental Water is the largest lake in Wanstead Park, comprising 6.07 hectares of water and 4.05 hectares of islands. It is also arguably the most aesthetically pleasing. However, as with the Heronry Pond, difficulty is encountered in maintaining the water level during summer. When required water is pumped from the adjacent River Roding, but this may only be done to a certain extent and when the conditions of the river are correct as informed by the river authority. Thus all too often considerable areas of mud are exposed, which soon dries hard allowing invasion of the two larger islands by children and adults alike. These islands would otherwise serve as a sanctuary for the flora and fauna. There is also a small round island in this lake, as well as the Fortifications, a group of small islands largely overgrown with bramble *Rubus fruticosus* agg. and ivy *Hedera helix,* and are rarely ventured upon by the general public.

The large size of the Ornamental Water and the great length of its winding bank provide a considerable range of habitats for a variety of plants growing both in and around the water. Yellow water lily *Nuphar lutea* grows in profusion opposite the Grotto as well as in that part of the lake which forms a fine ornamental 'canal'. Hornwort *Ceratophyllum demersum* and duckweed *Lemna minor* are common. Broad-leaved pondweed *Potamogeton natans* can be found at the north end of the lake in particular. Gipsywort *Lycopus europaeus* and cuckoo flower *Cardamine pratensis* occur all around the lake on the banks, and in the mud puple loosestrife *Lythrum salicaria* and water pepper *Polygonum hydropiper* abound.

The Dell

Situated between the Perch Pond and the Ornamental Water is a muddy, tree-filled hollow known as The Dell. Water flows through this area from the Perch Pond and flows over a concrete dam into the Ornamental Water. The dam maintains a depth of water of about six inches at the outflow and maintains the

marshy environment in the whole of The Dell. Alders and birches are the dominant trees here and reed grass *Phalaris arundinacea* is present in greater strength than *Glyceria maxima*. Water forget-me-not *Myosotis scorpioides* can be found here too and, apart from a small patch close by in the Ornamental Water, is not known to grow elsewhere in the park. Yellow loosestrife *Lysimachia vulgaris* also grows here but the dotted loosestrife *L. punctata* recorded by Jermyn (1975) has been found only in Reservoir Wood.

The River Roding

The east bank of the river, unlike the western side, is almost totally treeless, apart from the area called Whisker's Island. In addition the vegetation of this bank is regularly mown by the river authorities. However, in early summer before mowing, cow parsley *Anthriscus sylvestris,* nettle *Urtica dioica* and white dead-nettle *Lamium album* are common. Some plants less common in the rest of the park are found here too. These include lady's bedstraw *Galium verum,* meadow cranesbill *Geranium pratense* and lucerne *Medicago sativa*. The latter may have originated from the nearby allotments, and also grows in great quantity in the nearby sewage treatment works. A double-flowered variety of soapwort *Saponaria officinalis* must also be an escape. Whisker's Island, although not a true island today, is a triangular patch of trees with the river along one edge and a damp ditch running along the other two. The area has much bramble, but the plant of particular interest here is lesser water-parsnip *Berula erecta*. By the river itself, nearer to the footbridge that leads to the rest of the Park, branched bur-reed *Sparganium erectum* has been found. *S. emersum,* noted by Jermyn (1975), has not yet been located by us. In the river at this point grows arrowhead *Sagittaria sagittifolia,* whilst on the west bank of the river is a specimen of crack willow *Salix fragilis.*

The Bund

This area was created in 1972 when an attempt was made to dredge the Ornamental Water which was in an advanced state of eutrophication. Preceding this a large number of trees and much holly *Ilex aquifolium* were felled around the lake to prevent leaves from falling into the water. The dredgings from the lake were pumped to the site of what is now called The Bund, where the water drained slowly back into the lake. The result was a large expanse of mud on what was once deciduous woodland.

The first plants to colonize this area were predictably wetland plants, presumably from the lake itself. Great reedmace *Typha latifolia* was amongst the first to appear, but full investigation of the early stages of colonization was not possible because the depth and soft nature of the silt made access impossible. Recolonization of the clay banks around the silt, now largely levelled, is better documented and in 1974, two years after completion of the banks, 45 species of plants were recorded there, including coltsfoot *Tussilago farfara,* which in 1979 is the largest patch of this species in the Park. For a time prickly lettuce *Lactua serriola* became abundant on the dried-out silt area, but in 1979 willow scrub is taking over to a large extent. A variety of vetches is present, including *Vicia cracca, V. sativa, V. hirsuta* and *V. tetrasperma*. Other plants found here include cut-leaved cranesbill *Geranium dissectum,* comfrey *Symphytum officinale,* various species of dock *Rumex* and daisy *Bellis perennis,* which is not common in the Park.

River Wood and the islands of the Ornamental Water

The area between the river and the Ornamental Water north of the Canal is known as River Wood. The trees here are of a variety of species including a number of ash *Fraxinus excelsior,* sycamore *Acer pseudoplatanus* and field maple

Acer campestre. In some parts cow parsley *Anthriscus sylvestris* is the dominant species, whilst in other areas it is nettle *Urtica dioica.* Near the Fortifications meadowsweet *Filipendula ulmaria* can be found. Passing around the northern end of the Ornamental Water there is another patch of daisies just beyond the shade of a stand of fine horse-chestnut trees *Aesculus hippocastanum.* Opposite this point narcissi *Narcissus x biflorus* are established on Lincoln Island, and amongst these are a few flowers of both *Narcissus poeticus* and *N. pseudonarcissus.* A solitary Scots pine *Pinus sylvestris,* also on Lincoln Island slightly further on, is the only example of this species in the Park.

Warren Wood, Chalet Wood and The Grove

West of the north end of the Ornamental Water the land rises sharply from under 10m to over 20m above sea level to form the higher part of Warren Wood. Until recent years this wood was largely composed of elm *Ulmus* sp. Since the recent epidemic of Dutch elm disease all of the elm trees have died. In the interests of public safety most of the dead trees have been removed. With the clearance went much of the undergrowth, a good deal of the top soil having been bulldozed away. These events have had a great effect on the wood and its flora. Where once flourished the bluebell *Endymion non-scriptus,* a plant characteristic of shaded woodland floors, is an area of soft rush *Juncus effusus* and literally thousands of sycamore saplings amongst the elm suckers arising from remaining stumps. The fungal flora is of interest but is outside the scope of this paper. Willowherbs *Epilobium* sp., Canadian golden rod *Solidago canadensis,* red campion *Silene dioica* and *Buddleja davidii* are all growing here and there is a small number of plants of scarlet pimpernel *Anagallis arvensis.* Barren brome *Bromus sterilis* is a prominent grass. A patch of wood anenome *Anenome nemorosa* has on the other hand benefited greatly from the clearance of elms; where there was once only a single small patch a few years ago there are now several larger patches. Lesser celandine *Ranunculus ficaria* is abundant. As the floor of the wood falls to the south-east, more of the trees and the undergrowth remain, although since the trees are in the main part dead elms light penetration is still greater than it was and the flora has changed. There are some good specimens of hornbeam *Carpinus betulus* here. At the very edge of the wood, half way up The Glade, common dog violet *Viola riviniana* grows. Nearer to the Ornamental Water, again at the edge of the wood, there is a patch of ivy-leaved speedwell *Veronica hederifolia,* which appears to be spreading. At the edge of the lake at the bottom of the Glade is a solitary cedar of Lebanon *Cedrus libani,* leaning over the water and in danger of toppling.

Across the Glade from Warren Wood is the Grove. Like Warren Wood, all of the elms are now dead, and many have been felled, but surprisingly the bluebells flourish, in a less than typical open situation, but with rushes becoming more abundant. There are some yews *Taxus baccata* around the Grotto, where an ornamental mock orange *Philadelphus coronarius* occurs, along with purple flowered *Rhododendron ponticum.* Further up this side of the Glade is a solitary Weymouth pine *Pinus strobus.* At this point the wood is called Chalet Wood, where many of the elms were lost as long ago as 1953 and consequently there are few mature trees. The wood at this point is dense, and includes silver birch *Betulus pendula* and hairy birch *B. pubescens.* These species hybridize freely in the Park. White poplar *Populus alba* is also present and seeds readily. Chalet Wood is perhaps the best area of the park for cryptogams. Bracken *Pteridium aquilinum,* male fern *Dryopteris filix-mas* and buckler *D. dilatata,* have been found but *D. pseudomas,* recorded by Jermyn (1975), is apparently absent. At the edge of the track through the wood leading to the Keeper's Lodge is a magnificent mature specimen of sweet chestnut *Castanea sativa.*

The Glade provided Wanstead House with a view between the woods, across the Ornamental Water and along the Canal, and though the house has gone the view remains. The top of the Glade is open, and signs of rabbits *Oryctolagus cuniculus* may be seen. The grasses here include meadow foxtail *Alopecurus pratensis*, brown bent *Agrostis canina montana*, Yorkshire fog *Holcus lanatus* and creeping fescue *Festuca rubra rubra*. Other plants include meadow vetchling *Lathyrus pratensis*, creeping buttercup *Ranunculus repens* and black knapweed *Centaura nigra*. There is a tree of heaven *Ailanthus altissima* growing by the park fence. Further down the Glade the grasses smaller cat's tail *Phleum bertolonii* and crested dog's tail *Cynosurus cristatus* occur.

The Plain

South of the Grove and Chalet Wood is an open grassland area known as The Plain. Since the removal of an avenue of English elm *Ulmus procera* that crossed the area, this now presents an even more open aspect. Adjacent to the Keeper's Lodge is a building known as The Temple, which is an ornamental garden house built after the style of the former Wanstead House. It is now used as storage rooms. The small enclosed garden to The Temple consists of a carefully tended lawn surrounded by small trees and ornamental shrubs. Amongst these are *Aucuba japonica* and *Mahonia aquifolium*. There is also a single yucca, probably *Yucca gloriosa*, in the grounds. In front of the buildings on the Plain stands a solitary wellingtonia tree *Sequoiadendron giganteum* inside a fenced surround. Apart from various grasses, other plants to be found on The Plain include an area of broom *Cytisus scoparius*, sheep's sorrel *Rumex acetosella*, and field bindweed *Convolvulus arvensis*. At the west end near the fence frow some small trees, including English oak *Quercus robur*, a domestic variety of apple *Malus* and birch hybrids *Betula pendula x pubescens*. Here too may be found common sorrel *Rumex acetosa* and rosebay, *Chamaenerion angustifolium*. Outside the enclosure, between the Heronry and Shoulder of Mutton Ponds, are two walnut trees *Juglans regia* and some balsam poplar, *Populus gileadensis*.

Doubtless there are other species of plants still to be found and identified in Wanstead Park, and even the most frequently walked path could still produce an overlooked or unrecognized specimen. A seach of available literature has revealed eleven species recorded in recent years and absent from the present records. The following are recorded by Jermyn (1975):

Dryopteris pseudomas
Hippuris vulgaris
Calluna vulgaris
Galium saxatile
Butomus umbellatus
Sparganium emersum
Schoenoplectus tabernaemontani
Molinia caerulea
Festuca tenuifolia
Alopecurus aequalis

These may not all have been found within the boundaries of the study area defined earlier; indeed some have been found nearby, for example, *Galium saxatile* which is present in the City of London Cemetery just to the south. Also *Senecio viscosus* was recorded in Wanstead Park, on 3 September 1927 by F. C. Owen, and recorded in his notebook which is now at the Passmore Edwards Museum. A search of the herbarium material at the Museum, particularly that collected by Lister, will without doubt reveal other species apparently no longer present. Since this material covers the whole of Epping Forest, any relevant information derived from it will be summarized for the whole of the study area in the final part of this paper.

It is also certain that much work needs to be done on the status of the species recorded in this paper. Generally, in the list that follows, we have not felt competent to describe the frequency of individual species. However where it is known that a plant is rather uncommon or even rare in Wanstead Park this has

been stated. Similarly, there are instances where it has been stated that a species is abundant. In the absence of any comment therefore it should be assumed that the species is thought to be fairly prevalent but that there is no concrete evidence to support this.

The sequence of plants in the list follows the order and nomenclature of Clapham, Tutin and Warburg (1962). The letters and numbers after some of the entries refer to the squares shown in Fig. 2, each square being 0.25 x 0.25km.

Acknowledgments

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TABLE 1. Plants recorded in Wanstead Park during the years 1975 to 1979.

Abbreviations	HP	Heronry Pond
	OW	Ornamental Water
	PP	Perch Pond
	SM	Shoulder of Mutton Pond

PTERIDOPHYTA

Pteridium aquilinum bracken. Mainly Warren Wood and Chalet Wood.
Dryopteris filix-mas male fern. Mainly Chalet Wood.
D. dilatata buckler fern. Mainly Chalet Wood.

GYMNOSPERMAE

Cedrus libani cedar of Lebanon. Single tree by OW in M8.
Pinus sylvestris Scots pine. Single tree on Lincoln Island L9.
P. strobus Weymouth pine. Single tree by Glade in L8.
Sequoia wellingtonia Wellingtonia. A single tree on Plain L7.
Taxus baccata yew. A few trees in L7, M7 and N6.

ANGIOSPERMAE : DICOTYLEDONES

Anemone nemorosa wood anemone. Restricted to Warren Wood K9.
Ranunculus acris meadow buttercup.
R. repens creeping buttercup.
R. bulbosus bulbous buttercup.
R. sceleratus celery-leaved crowfoot.
R. peltatus pond water-crowfoot. Abundant in HP.
R. ficaria lesser celandine. Common in woodland areas.
Mahonia aquifolium Oregon grape. Only as part of hedge around the Temple L7.

Nuphar lutea yellow water-lily. Uncommon. In OW opposite the Grotto M7; in canal N8.
Ceratophyllum demersum hornwort.
Papaver rhoeas common poppy. Uncommon. By Northumberland Avenue, 1979.
Brassica oleracea cabbage. Uncommon. In the Dell in 1977.
Sinapis arvensis charlock. Uncommon.
Cardaria draba hoary cress.
Capsella bursa-pastoris shepherd's purse.
Lobularia maritima sweet alison. One plant by house fence I6.
Lunaria annua honesty. Uncommon.
Cardamine pratensis cuckoo flower.
C. hirsuta hairy bittercress. Uncommon. On disturbed ground in K9, 1977.
Barbarea vulgaris common wintercress.
Rorippa nasturtium-aquaticum watercress. Uncommon. By Roding N6.
R. sylvestris creeping yellowcress. Uncommon. East end of PP, M6.
R. amphibia greater yellowcress.
R. palustris marsh yellowcress. Uncommon. West end of HP, J7.
Alliaria petiolata garlic mustard.
Sisymbrium officinale hedge mustard.
Viola riviniana common dog-violet. Uncommon. At the edge of the Glade in L8.
V. tricolor wild pansy. One plant only found by PP, M6. Probably a stray seedling from a garden hybrid pansy.
V. arvensis field pansy. Only known in garden of Keeper's Lodge.
Hypericum perforatum perforate St John's wort. Uncommon.
Silene dioica red campion. Scattered in woodland.
S. alba white campion. Uncommon. Occurs in the Bund, N8.
Saponaria officinalis soapwort. Uncommon. A double-flowered form found near houses on the east bank of the Roding L10; also at back of houses in Woodlands Avenue H6.
Cerastium holosteoides common mouse-ear. Uncommon. In Bund N7.
Myosoton aquaticum water chickweed. Uncommon. In ditch around Whisker's Island N8.
Stellaria media common chickweed.
S. graminea lesser stitchwort. Uncommon. Occurs at the top of the Glade in K8. and east end of the Plain in M7.
Sagina procumbens procumbent pearlwort.
Spergula arvensis corn spurrey.
Chenopodium album fat hen.
C. rubrum red goosefoot. Uncommon. OW bank side.
Atriplex hastata spear-leaved orache.
Tilia x europaea common lime. Uncommon. In various locations.
Malva sylvestris mallow. Uncommon. Mainly on Roding bank.
Geranium pratense meadow cranesbill. Uncommon. On east bank of Roding in M9.
G. dissectum cut-leaved cranesbill. Uncommon. In Bund N7.
Oxalis acetosella wood sorrel. In Warren Wood in 1975, but not found since.
Ailanthus altissima tree of heaven. One tree at the top of the Glade K8.
Acer pseudoplatanus sycamore.
A. campestre field maple. Uncommon.
A. platanoides Norway maple. Uncommon. At rear of Kiosk L6; south end of the Canal N8.
Aesculus hippocastanum horse chestnut.
Ilex aquifolium holly.
Ulex europaeus gorse. Uncommon. A few bushes mainly near SM and HP.
Sarothamnus scoparius broom. Uncommon.
Medicago sativa lucerne. Common on River Roding bank, particularly near allotments and by Whisker's Island N8.
M. lupulina black medick.
Melilotus officinalis ribbed melilot. One plant found between OW and Warren Wood in L9, 1977.
Trifolium repens white clover.
T. pratense red clover.
Lotus corniculatus birdsfoot trefoil.
Robinia pseudoacacia locust tree. A few trees in M6 and N6.

Galega officinalis goat's rue. Uncommon. On Roding bank in 1976.
Vicia hirsuta hairy tare. Uncommon. Occurs in Bund N7/8.
V. tetrasperma smooth tare. Uncommon. N7/8.
V. cracca tufted vetch. Most common in Bund.
V. sativa common vetch. Common at top of Glade K8.
Lathyrus nissolia grass vetchling. One plant found between OW and Warren Wood in 1975.
L. pratensis meadow vetchling. Common.
Filipendula ulmaria meadowsweet. One plant by OW in M8.
Rubus idaeus raspberry. Uncommon. Growing amongst brambles in The Bund N7/8.
R. fruticosus agg. bramble. Abundant.
Potentilla erecta tormentil. Uncommon. At top of Glade K8.
P. reptans creeping cinquefoil.
Geum urbanum herb bennet.
Prunus spinosa blackthorn. A bush on island of HP, K7.
P. avium wild cherry. Uncommon.
Crataegus monogyna hawthorn.
Sorbus aria common whitebeam. Uncommon. By Dell M6 and near end of Canal N8.
Pyrus communis pear. One tree in Reservoir Wood H6.
Malus sp. apple. One by west end of HP; one at west end of Plain K7; one near sewage works fence N6.
Platanus x hybrida London plane.
Philadephus coronarius mock orange. One plant near Grotto M7.
Lythrum salicaria purple loosestrife.
Peplis portula water purslane. Uncommon. West end of PP, L6.
Epilobium hirsutum great willow-herb.
E. montanum broad-leaved willow-herb.
E. adenocaulon American willow-herb.
E. tetragonum square-stemmed willow-herb.
Chamaenerion angustifolium rosebay willow-herb.
Circaea lutetiana enchanter's nightshade. Uncommon. In Warren Wood L8/9; Reservoir Wood near Blake Hall Road H7.
Aucuba japonica aucuba. As part of hedge around Temple garden L7.
Hedera helix ivy.
Anthriscus sylvestris cow parsley.
Conium maculatum hemlock. Uncommon. By River Roding bank N7.
Apium nodiflorum fool's watercress. West end of HP, JK/6.
Berula erecta lesser water-parsnip. Common only in ditch by Whisker's Island N/O8.
Heracleum sphondylium hogweed.
Daucus carota wild carrot. A few plants in The Bund N7/8.
Bryonia dioica white bryony. Uncommon. In woodland.
Mercurialis perennis dog's mercury. Uncommon. In Warren Wood L8/9.
Polygonum aviculare knotgrass.
P. amphibium amphibious bistort.
P. persicaria persicaria.
P. lapathifolium pale persicaria. Uncommon. In the Bund N7.
P. hydropiper water pepper.
Rumex acetosella sheep's sorrel.
R. acetosa common sorrel. Uncommon. West end of Plain K7 and by Northumberland Avenue K6.
R. crispus curled dock.
R. obtusifolius broad-leaved dock.
R. conglomeratus clustered dock.
Urtica dioica stinging nettle.
Cannabis sativa hemp. Uncommon.
Ulmus glabra wych elm. Population devastated by Dutch elm disease, but many stumps suckering profusely.
U. procera English elm. Suckers only.
U. x hollandica Dutch elm. Seven trees in 17, 1975, now dead.
Juglans regia walnut. Two trees in 17.
Betula pendula silver birch. A few trees.
B. pubescens hairy birch. A few trees.
B. pendula x pubescens hybrid birch. Most birch trees in the park seem to be this hybrid.

Alnus glutinosa alder. Particularly by PP and in Dell.
Carpinus betulus hornbeam. Scattered locations through park.
Fagus sylvatica beech. A number of specimens throughout the park.
Castanea sativa sweet chestnut. A few trees.
Quercus robur English oak.
Q. petraea x robur hybrid oak. One or two specimens.
Q. cerris Turkey oak. One tree in N7.
Populus alba white poplar. Regenerating freely in Chalet Wood K/L7.
P. gileadensis balsam poplar. A few trees near SM.
P. x canadensis var. *serotina* black Italian poplar. A tree by SM, I7.
Salix fragilis crack willow. A number of trees in carious locations I6, J6, K6, L10, M6, M8/9, and N6.
S. caprea great sallow. Particularly by PP and Bund.
Rhododendron ponticum purple rhododendron. Occurs in Chalet Wood, Warren Wood and The Grove.
Lysimachia vulgaris yellow loosestrife. In Dell M6 and by OW near Grotto M7.
L. punctata dotted loosestrife. Uncommon. Only at edge of Reservoir Wood near SM, I6/7.
Anagallis arvensis scarlet pimpernel. One location by Warren Wood near OW.
Buddleja davidii buddleia. One plant in Warren Wood K9.
Fraxinus excelsior ash.
Symphytum officinale common comfrey. Mainly in Bund and by River Roding.
Pentaglottis sempervirens green alkanet. One plant known in ditch in Reservoir Wood H6.
Myosotis scorpioides water forget-me-not. Only in the Dell M6.
Convolvulus arvensis field bindweed. Uncommon. In grass at west end of Plain K7.
Calystegia sepium sepium hedge bindweed. Uncommon. On Roding river bank.
C. sepium silvatica great bindweed. Uncommon. Near River Roding.
Solanum dulcamara bittersweet. Scattered throughout park.
S. nigrum black nightshade. Uncommon. On island of HP, K7; by main track to Keeper's Lodge L7.
Scrophularia nodosa common figwort. A few plants, K/L8/9, L7, M9.
Digitalis purpurea foxglove. Uncommon. By sewage works fence N7; in Warren Wood K8; by main track to Keeper's Lodge L8.
Veronica serpyllifolia thyme-leaved speedwell. One plant found in Bund 1976.
V. hederifolia ivy-leaved speedwell. Increasingly common. At bottom of Glade by Warren Wood M8; on car-park clearing I/J6.
Mentha aquatica water mint. Particularly on banks of OW; near the Grotto M7; and elsewhere.
Lycopus europaeus gipsywort.
Stachys sylvatica hedge woundwort. Uncommon. In Bund and OW banks.
Ballota nigra black horehound. Uncommon. Between Warren Wood and OW, L9.
Lamium purpureum red dead-nettle.
L. album white dead-nettle.
L. maculatum spotted dead-nettle. Edge of Reservoir Wood H6. Probably garden escape.
Glechoma hederacea ground ivy.
Scutellaria galericulata skullcap. Uncommon. By OW and in Bund.
Plantago major greater plantain.
P. lanceolata ribwort plantain.
Campanula rotundifolia harebell. A patch at top of Glade K8.
Galium verum lady's bedstraw. Uncommon. On east bank of Roding M2.
G. aparine cleavers.
Sambucus nigra elder.
Symphoricarpos rivularis snowberry. One plant only, at west end of Reservoir Wood near ditch by houses G6.
Helianthus annuus sunflower. One plant on the mound in Warren Wood L7 in 1978.
Bidens tripartita trifid bur-marigold. Particularly by OW.
Senecio jacobaea common ragwort. Uncommon. Bund N7; wood L8.
S. squalidus Oxford ragwort.
S. vulgaris groundsel.
Tussilago farfara coltsfoot. Most common in Bund; also by OW, M7.
Solidago canadensis Canadian golden-rod. Uncommon. Occurs in N7/8 and L9.
Aster novi-belgii Michaelmas daisy. Uncommon. A few scattered plants, N7/8 and K9.

Conyza canadensis Canadian fleabane. Uncommon. On banks of HP.
Bellis perennis daisy. Uncommon. N7, L8, L10.
Achillea ptarmica sneezewort. A double-flowered form by River Roding M9 in 1977.
A. millefolium yarrow.
Tripleurospermum maritimum scentless mayweed.
Matricaria recutita scented mayweed.
Chrysanthemum leucanthemum ox-eye daisy. Uncommon. On east bank of Roding near allotments.
C. maximum shasta daisy. A small group at top of Glade J8 in 1979.
Artemisia vulgaris mugwort. Uncommon. A few plants on Roding bank and between OW and Warren Wood.
Arctium minus lesser burdock. Uncommon. At east end of Plain by Chalet Wood K7.
Carduus acanthoides welted thistle. Uncommon. In Bund and by Roding.
Cirsium vulgare spear thistle.
C. arvense creeping thistle. Particularly common in Bund.
Centaurea montana perennial cornflower. Two plants found by track at back of Woodlands Avenue 16 in 1977.
C. nigra black knapweed. Uncommon. At top of Glade K8 and by Roding river bank.
Lapsana communis nipplewort. Uncommon. A plant near houses on east bank of Roding L10 in 1977. One plant found in River Wood by track M8 in 1979.
Hypochoeris radicata common catsear.
Picris echioides bristly ox-tongue.
P. hieracioides hawkweed ox-tongue. Uncommon. By footpath at south side of PP, L6, in 1977.
Lactuca serriola prickly lettuce
Sonchus oleraceus smooth sow-thistle.
S. asper prickly sow-thistle.
Hieracium sp. leafy hawkweed. Uncommon. Bund.
H. pilosella mouse-ear hawkweed. Uncommon. At east end of Plain K7.
Crepis vesicaria beaked hawksbeard. Uncommon. At west end of the Bund N7.
C. cappillaris smooth hawksbeard.
Taraxacum officinale agg. dandelion.
T. laevigatum agg. lesser dandelion. Uncommon. On the Plain.

ANGIOSPERMAE : MONOCOTYLEDONES

Alisma plantago-aquatica common water plantain. Uncommon. In OW, N7 and L10.
A. lanceolatum narrow-leaved water plantain. Uncommon. In River Roding by bridge N6.
Sagittaria sagittifolia arrow-head. Uncommon. In River Roding by bridge N6.
Elodea canadensis Canadian pondweed. In OW, HP and SM.
Potamogeton natans broad-leaved pondweed. Uncommon. In OW.
Endymion non-scriptus bluebell. Common in woodland.
Muscari sp. grape-hyacinth. One plant only near park gates by Northumberland Avenue L6.
Yucca gloriosa. Planted in garden of Temple L7.
Juncus effusus soft rush. Common in a number of locations.
J. inflexus hard rush. One patch by SM, 17.
Luzula campestris field wood-rush. Uncommon. East end of Plain between Chalet Wood and park fence K7.
Narcissus x biflorus primrose peerless. A patch on Lincoln Island in L9. Various types of daffodils including garden varieties occur in the park, especially in Warren Wood.
N. pseudonarcissus wild daffodil. A few on Lincoln Island L9.
N. poeticus poet's narcissus. A few on Lincoln Island L9.
Iris pseudacorus yellow flag iris. At west end of PP, L6, and at east side of SM, 16.
Crocuspurpureus spring crocus. One plant in Warren Wood K9.
Crocus spp. Mostly growing in Reservoir Wood near to Woodlands Avenue houses, perhaps garden escapes.
Arum maculatum cuckoo pint. A few locations in K7, K9, N6.
Lemna minor common duckweed. Abundant, especially in OW.
Sparganium erectum branched bur-reed. Uncommon. By Roding Bridge in N6/7.
Typha latifolia great reedmace. Appeared in the Bund after completion in 1972 but is not now present. It does, however, occur by water just to the south of Wanstead Park.
Eleocharis palustris common spike-rush. Common in the Bund; OW, SM.

Carex riparia great pond sedge. Uncommon. At west end of PP, L6.
C. hirta hairy sedge. Uncommon. In Grass by HP, K6; by SM, I6.
Glyceria fluitans floating sweet-grass. Uncommon. At west end of HP, J6/7.
G. x pedicellata hybrid sweet-grass. Uncommon. At west of end of HP, J6/7.
G. maxima great water-grass. By OW and SM. Forming dense bed at west end of PP. Also in Dell.
Festuca rubra rubra red or creeping fescue.
Lolium perenne perennial rye-grass.
Poa annua annual meadow-grass.
P. nemoralis wood meadow-grass.
P. pratensis smooth meadow-grass.
P. trivialis rough meadow-grass.
Dactylis glomerata cocksfoot.
Cynosurus cristatus crested dogstail.
C. echinatus rough dogstail. Uncommon. At top of grass bank between OW and Warren Wood, K/L9.
Anisantha sterilis barren brome.
Bromus mollis soft brome.
Agropyron caninum bearded couch. Probably uncommon. In River Wood L10.
Hordeum murinum wall barley. Mainly by Northumberland Avenue.
Arrhenatherum elatius false oat-grass.
Holcus lanatus Yorkshire fog.
H. mollis creeping soft-grass.
Agrostis canina montana brown bent.
A. tenuis common bent.
Apera spica-venti loose silky-bent. Woodland near Roding, 1977.
Phleum pratense timothy.
P. bertolonii smaller catstail.
Alopecurus pratensis meadow foxtail.
Phalaris arundinacea reed Canary grass. Occurs in OW, the Bund, and the Dell where it is the predominant reed-grass.

Book Review

The Mule: a Historic Hybrid. By T. H. Savory. 49 pp. Meadowfield Press, Shildon, Co. Durham. 1979. £2.80.

Theodore Savory will be better known to London's naturalists for his many papers and books on spiders. In this little paperback, an extension of an article that appeared in *Scientific American* in 1970, he gives a very readable account of the history, genetics and folklore of the mule, marred only by almost indecipherable photographs. Mules at one time played a dominant role in war and trade, pulling wagon trains across the American west and carrying loads on mountain tracks in the Himalayas (as they still do). Mules are rarely seen now in most of the world but in spite of quotes such as 'The Democratic Party is like a mule — without pride of ancestry or hope of posterity', the mule may have the last laugh over other 'endangered species' since it can be recreated at will. The traditional skills that went with their breeding and handling might be more difficult to recreate.

In mentioning other interspecific hybrids the author slips up in saying that crosses have been obtained between a rabbit and a guinea-pig. In mammals intergeneric crosses are rare, those between more distantly related species unknown.

G. B. Corbet

The Ecology of the River Cray at Foots Cray, Kent, and Recovery from Pollution and Dredging

by BRIAN KNIGHTS*, DEBBIE J. FOOT* and ANN E. RUMPUS*

Summary

The ecology of part of the River Cray, Kent, was studied from October 1978 to January 1980 following a caustic soda pollution accident and subsequent dredging. The distribution of macroinvertebrate species was related to current speed. The increases in density and changes in community structure in the faster-flowing regions indicated that full recovery was attained by the end of the study due mainly to recolonization from up-river and post-pollution breeding. Recovery in the lentic-lacustrine regions was slower and followed the accumulation of sediments after dredging in the Five Arches part of the River. It is concluded that despite being vulnerable to pollution spills, eutrophication and siltation, the River is of generally good quality and able to support a good coarse fishery.

Introduction

The River Cray rises in Priory Gardens, Orpington, in the Borough of Bexley and flows for 14km northwards before joining the River Darent and entering the Thames at Dartford. It passes along the urbanized and industrialized Cray Valley, flowing through Ruxley Lakes before reaching the study area (Fig. 1). This is a series of four open shallow gravel pits of 11.7ha forming a fishing club water and also a nature reserve administered by the Kent Trust for Nature Conservation. Heal and Bailey (1974) showed that settlement of suspended solids and biological purification occurs as water flows through the three main lakes of the series whilst more water is derived from springs in the remaining one (East Lake). The water leaves the last lake (North Lake) in a potentially clean state via a fish screen and weir. The river subsequently flows through a culvert under the A20 trunk road and then through the industrial estate at Foots Cray before entering the open parkland of Foots Cray Meadows. This is public land, formerly part of the Foots Cray Place Estate. The river here is three to four metres wide on average with a gravelly stony bottom and lined with trees. There is no evidence of persistent pollution and the Thames Water Authority consider the river to be of good quality for an urban water course (Aston *et al.* 1979 and Aston and Andrews 1978). It is vulnerable to accidents, however, and ten spillages of pollutants occurred between 1974 and 1978. None was as serious as that due to a spillage of caustic soda from industrial premises on 12 April 1978, which killed at least 6,000 coarse fish, among which were thousands of sticklebacks and minnows, downstream of Foots Cray. Two further known pollution spillages occurred during the period of this study in early October 1979, one involving diesel oil and the other involving latex rubber solution (see below for further discussion).

The river in Foots Cray Meadows is of further interest because a weir beneath a decorative bridge dams back the waters to form approximately 0.64ha of open water called Five Arches Lake (Grid Reference TQ481718). This is an important local amenity area and public angling spot. A discrete 'plug' of a pollutant passing down river might be expected to be held back in this area and the longer

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the retention time, the greater the environmental and aesthetic damage. The Lake traps large amounts of sediments and organic material from the parkland and riverine vegetation upstream. In addition, run-off from roads and industrial premises adds to sediment burdens and perhaps chemical pollution. Such effects may well be more severe in the future if plans proceed to improve the A20 trunk road and run-off increases during construction and with subsequent higher traffic loads.

Prior to the fish kill, TWA were going to restock Five Arches Lake and continued sedimentation had led to plans for dredging to improve fisheries and form a canoe circuit. Dredging was completed in June 1978 (with aid from TWA and the Queen's Jubilee Fund) to form a deeper circuit around the islands of about 1.5m depth. Some 5,900 fish (mainly roach, tench, bream and chub) weighing 200kg in total were stocked, once TWA biologists felt invertebrate food sources were adequately re-established. This (plus later stocking) produced a biomass of about 20gm/m^2. The present study was begun in September 1978, as initial restocking was being completed in order to assess any longer term effects of the pollution spill and dredging, to follow the recovery process over 17 months and to provide detailed base line data for future reference. Samples were taken between September 1978 and January 1980 in the riverine and more lacustrine parts of the Cray at Five Arches to assess water quality and to examine the composition and relative abundance of the benthic invertebrate fauna. In addition, some studies were made of the upriver stretch just below Ruxley Lakes and of organisms carried out of the Lakes to see how important these might be as sources of organisms for recolonization.

Methods

Study Sites

Five Arches was surveyed (Fig. 1) and sampling stations chosen to represent both riverine and lacustrine habitats where moderately deep water could be reached by wading.

(i) Station 1 was located in the river some 200m above the Lake and 500m below the source of the caustic soda spillage and 1,100m below Ruxley Lakes. Flow was quite fast (averaging 43cm s^{-1}) and the bed was of scoured gravel and stones, well banked and overhung by trees. River width was about 5.4m, depth 30–35cm. There was no vegetation at the station itself but there were clumps of *Callitriche* and *Elodea* just up-and downstream from late 1978 onwards. The small culvert shown on the map downstream of Station 1 drained the parkland and contributed less than two per cent of the main river flow.

(ii) Stations 2 and 3 were chosen as representative of regions of slowing current speed (27 and 7cm s^{-1} averages respectively). The river widened progressively and became more silty at Station 3, deposition increasing throughout the study period. Station 2 was more gravelly with large clumps of *Callitriche* sp. Most of the river flow passes along the east side of the lake with currents being slightly higher closer to the islands in the dredged canoe channel.

(iii) Station 4 was chosen as it would be expected to represent a mixture of more 'riverine' conditions from the east side of the Lake and more 'lacustrine' conditions from the west side (Station 6, see below). It had a deeper lakeward section but became shallower below the bridge where currents were stronger and scoured the gravel and stones clean before water passed over the weir. Average current speed was 39cm s^{-1}.

(iv) Station 5 was situated below the weir and by-pass culvert. The river was wide and shallow with consequent high current speeds (average 56cm s^{-1}). When

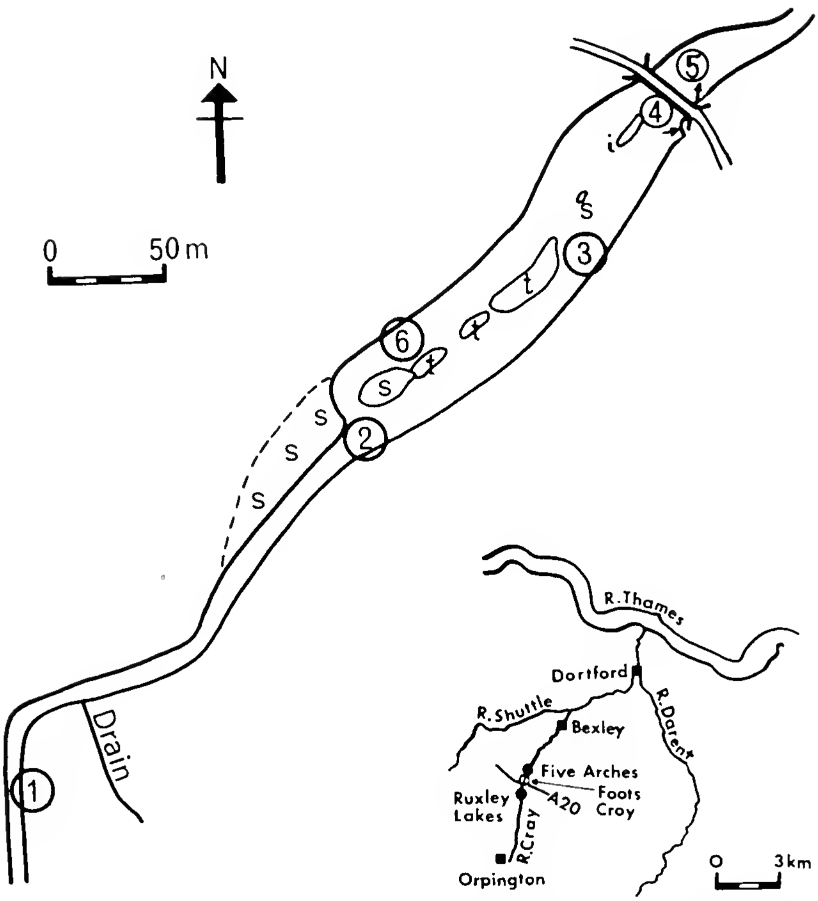

FIG. 1. Map of Five Arches Lake and parts of the River Cray (plus insert to show general location). Station numbers are shown, as is the sluice (arrows) which by-passes the weir under the bridge. Dominant vegetation is shown as s, *Salix* sp., t, *Typha* sp., and i, *Iris pseudacorus*. Some trees and clumps of *Iris pseudacorus, Phragmites communis* and *Epilobium hirsutum* fringe the Lake.

volume flows fell, even slightly, regions of the gravel bed became exposed and dry. Species present would be expected to be indicative of downriver conditions, plus drift out of Five Arches.

(v) Station 6 was located on the west side of Five Arches and was more isolated from the main flow between Stations 1 to 5. Current speeds were effectively zero, except in the deeper dredged channel closer to the islands. This was the most lacustrine region, showing progressive post-dredging siltation and build-up of decaying leaves and other vegetation. Some *Cladophora* sp. weed blankets occurred at Stations 3 and 4 late in 1978 and 1979 but these were even more dense and extensive at Station 6.

(vi) In addition to the above, samples were occasionally taken upriver between the Ruxley Lakes outfall and the A20 culvert (Station UR) to provide data on the condition of the river before flowing through industrialized Foots Cray. Average current speed was 46cm s^{-1}. Occasional samples of organisms washed out of Ruxley Lakes were also taken with a fine-mesh drift net. This was a conical net, 90cm deep with a rigid mouth 40cm wide by 10cm high. It was anchored up to the lip of the six-metre wide weir where the overflow depth was less than 10cm. In this way, a fifteenth of the total outflow could be sampled during daylight and overnight. The net was emptied at dusk and dawn.

Sampling of benthic invertebrates and plankton

A catch-per-unit-effort method was used to collect reasonably quantitative samples in the river and lake. A five-minute collection period was divided into three minutes of general netting with a long-handled FBA hand net (eight meshes/cm), one minute turning stones and picking off attached organisms and one minute kicking. The latter involved 10 scraping kicks to disturb animals hiding in or clinging to the substratum so that they were carried in the current into the net held open just downstream. This method was inappropriate on silty and leaf-strewn substrata at Stations 3 and 6 and so five minutes were devoted to scooping and sorting through bottom material in addition to one minute general collecting. This ensured approximately the same area of bottom was sampled on both hard and soft substrate.

Rivers usually have only sparse plankton populations, if any, but the partly lacustrine nature of Five Arches suggested they might be a significant component of the biota and perhaps provide an important source of food for fish. Four samples were taken at each Station during autumn 1978 and spring and summer 1979 using a five-litre sampler which was allowed to drain through a phytoplankton net (180 meshes/25mm). The plankton was found to be very sparse, hence relatively few collections were made.

Measurement of physicochemical factors

Temperature and dissolved oxygen (by Winkler titration or oxygen electrode) were measured at 20 – 30cm depth at each Station visit except on the first occasion in October 1979. On all but five visits water samples from each station were analysed for BOD, i.e. Biochemical Oxygen Demand at 20°C over five days. Because some chemical pollutants can exert an oxygen demand but are not metabolized, or may be toxic, some permanganate values (PV) were derived. This involved titration of water with potassium permanganate. The mean PV was 3.9ppm and results indicated that BOD was an adequate measure and that organic chemicals in the water were largely of natural origin and easily biodegradable.

Samples were taken for pH measurement and then frozen for later analysis of one or more of suspended solids (ppm of filterable solids), chlorinity (by titration with silver nitrate) and alkalinity (by titration with hydrochloric acid and indicator). One series of water samples and some *Callitriche* were analysed for heavy metal content by atomic absorption spectrophotometry.

Because of the potential problems of pollutants being retained in the slow-flowing parts of Five Arches Lake, some estimates of current flows and 'residence times' were made as detailed below.

Results

General Observations

At no time was there any sign of unnatural mortality or pollution (other than the presence of unsightly urban and industrial debris). Oily films were occasionally released when disturbing sediments and whitish effluents were sometimes seen entering from a drain just below Ruxley Lakes overflow, but these appeared to have no detrimental effects. The oil and rubber latex spills in October 1979 also seemed to have caused no real harm.

Over the course of the study, it was noted that aquatic vegetation in the form of *Callitriche* in faster currents and *Cladophora* and *Spirogyra* in slower flows

increased in density, taking into account some winter die-back. There was also a continuing build-up of sediments in Five Arches Lake, especially following autumn leaf-fall.

The results indicated that current speed was a major factor affecting species distribution and abundance because of its effects on substrata, food supply and water quality. Thus the results for the fauna will be presented and discussed in two sections, first the more lotic-riverine and then the more lentic-lacustrine. Such a division is also useful because the riverine fauna would only have been affected by the caustic soda spillage, whilst the latter would also have been affected by dredging. First, however, physicochemical parameters will be considered. Concentrations are expressed in ppm (i.e. mg l^{-1}).

Physicochemical Measurements

(i) Current and volume flows

Surface current speeds were calculated at most sampling times by timing the movement of markers over measured distances. Several measurements were taken at each Station and averaged. Current speeds were inversely related to river depth and directly related to breadth and lack of sedimentation. They were always in the order: Station 5 (range 49 – 65cm s^{-1}); Station 1 (34 – 53); Station 4 (33 – 48); Station 2 (18 – 33); Station 3 (2 – 22); Station 6 (zero). Such results can only be approximations because of variations in current speed with depth, and obstructions across the river width.

Some estimates were made of volumes of water flowing through the study site by measuring water depths at 20cm horizontal intervals across the river, calculating profile area (m^2) and multiplying this by current velocity (m s^{-1}). Whilst open to many errors in calculation, figures for the same days for Stations 1 and 5 are in reasonable agreement (mean values 0.71 and 0.80m^3 s^{-1} respectively). More water enters the Cray further down its course (e.g., via a tributary, the Shuttle) to give a final average flow of about one m^3 s^{-1} according to Aston *et al.* (1979).

Average flow at Station UR was 0.31m^3 s^{-1} (range 0.12 – 0.58) whilst the same-day values at Station 1 give a mean of 0.61m^3 s^{-1} (range 0.36 – 0.71). The first result compares well with an estimate of outflow from Ruxley Lakes of 0.41m^3 s^{-1} made in 1963 (Chubb 1965). Downstream flow is probably augmented by extra underground drainage. Springs certainly supported large watercress beds in part of the Meadows before Ruxley Lakes were dug in the 1940s and later house building covered much of the area. Subsoil drainage would be expected to increase when water levels in Ruxley Lakes are high, but flows generally showed only minimal relationships to immediate rainfall because of the buffering capacity of the chalk aquifer. Lowest flows were found in December 1979 because dam boards were placed in the weir at Ruxley Lakes outlet to raise water levels. This is done in winter to aid flood control.

Knowing approximate flow rates and lake volumes, it is possible to make estimates of the residence time of the water in Five Arches. At the average flow rates calculated above and a lake volume of about 9,600m^3 (calculated by multiplying the surface area (6,400m^2) by average depth (1.5m)), water takes about three to four hours to pass through the lake. This is an overall approximation since most flow passes along the deeper channel to the east side of the islands giving a shorter residence time here but a potentially longer one on the west side (Station 6) and in shallower bankside regions. Residence times would have been shorter during the caustic soda spill in April 1978 because the lake was shallower on average before dredging. This, together with the large volume of the lake and the heavy fish kills, implies that the spillage must have been large and/or

very concentrated but passed downriver fairly quickly. Because most flow occurs along the east side of the lake, it is possible that more invertebrates survived along the west side and amongst the reeds on the islands, only to be decimated again by the later dredging. At times of low river flow, residence times would be much longer and pollution effects much greater (e.g. Aston *et al.* 1979, found average daily flows as low as $0.2m^3 s^{-1}$ in 1973).

(ii) Temperature, dissolved oxygen and BOD

Sampling was conducted in early to mid-afternoon and results are shown in Tables I and II. The seasonal temperature range was large, from 4 to 20.5°C, though the high heat capacity of the water meant its temperature tended to lag behind short term rises and falls in air temperature. Progressive solar warming caused temperatures to rise slightly as water passed slowly through the Lake. Those at Station 6 were sometimes lower than expected because of shading by trees; those at Station 1 reflected a balance between the temperature of water leaving Ruxley Lakes and subsequent equilibration with average air temperature. Temperatures were unusually high in early December 1979 because of mild weather.

TABLE I Distribution during study of afternoon temperatures (°C).

		Water at Station Number:-							Station
Date	Air	1	2	3	4	5	6	Mean	U R
22.9.78	17.5	16	16	16.5	17	16.5	17	16.5	—
18.10.78	11	11.5	12	12	11	11.5	12	11.7	—
15.11.78	13	11.5	12	12	11.5	11	11	11.5	—
16.12.78	7	6	6	6.5	6.5	6.5	6	6.3	—
8.2.79	5	4.5	4.5	4	4.5	5	4	4.4	—
22.3.79	8.5	8	8	8	8	8	8	8.0	—
24.7.79	20	16	16.5	17	17	17	17	16.8	20.5
31.8.79	20	17	17	17	17	17	17	17.0	—
5.11.79	15	11	11	10.5	10.5	10.5	10.5	10.7	10
6.12.79	15	11	11	11.5	11.5	11.5	10.5	11.2	10.5
4.1.80	11	6	6	6.5	6.5	6.5	6	6.3	5

TABLE II Distribution during study of afternoon dissolved oxygen (per cent saturation).

	DO at Station Number:-							Station
Date	1	2	3	4	5	6	Mean	U R
22.9.78	78.5	68.5	70	80.5	79	76	75.4	—
18.10.78	78	69.5	73.5	78.5	67	82.5	74.8	—
15.11.78	84.5	102	94.5	73.5	103.5	98	92.7	—
16.12.78	81	79	84.5	83	99	81	84.6	—
8.2.79	89	89.5	86.5	87.5	100	86	89.8	—
22.3.79	91.5	92.5	98	94	99	97.5	95.4	—
24.7.79	91	88	91	120	102	93	97.5	131
31.8.79	98	107.5	110.5	124	108.5	110.5	109.8	—
5.11.79	100	100	97	97.5	100	93	97.9	96.5
6.12.79	86.5	87	93	89	92	82	88.3	97
4.1.80	94	92	95	92	99	93	94.2	98
Mean	88.4	88.7	90.3	92.7	95.4	90.2	91.0	

The percentage dissolved oxygen (DO) at a given temperature is affected by a number of factors. Firstly, a high surface area-to-volume ratio and turbulence help to equilibrate DO with air and, secondly, oxygen saturation is increased by photosynthesis of algae and macrophytes but reduced by plant and microbial respiration. The latter group of factors appears to be of greatest importance in Five Arches Lake as might be expected in a more lentic ecosystem. In relation to

photosynthesis, it can be seen (Table II) that average dissolved oxygen (expressed as percentage of air saturation value) tended to increase as currents slowed between Stations 1 to 5 and this correlates with the amounts of algae seen (especially *Cladophora* and *Spirogyra*). Furthermore, average DO increased in late autumn 1978, fell in the late winter – early spring and then rose to much higher levels through 1979, again correlating with seasonal changes in algal density and their more extensive post-dredging spread in 1979.

BODs greater than 5ppm indicate considerable organic enrichment and potential eutrophication, figures below 3ppm indicate very clean water. The average BOD over the study was 4.1ppm, indicating a general good quality but values were variable between Stations and with time, ranging from 1.1ppm (December 1978, Station 1) to 10ppm (January 1980, Station 4). Twenty-two per cent of the fifty-seven values obtained were greater than 5ppm but only nine per cent exceeded 6ppm whilst twenty-five per cent were lower than 3ppm. BOD tended to increase as currents slowed and in the autumn (especially in the mild November – December of 1979) and following heavy rains in late December 1979, reflecting the accumulation of oxidizable nutrients brought down by the river, draining from the Meadows and being released from decay of leaves and other vegetation.

Despite these potential demands on available oxygen, saturations were generally quite high even to the point of supersaturation at the more lacustrine stations in late summer 1979. Heal and Bailey (1974) found a similar situation in Ruxley Lakes. Water from this source explains the supersaturation at Station UR in July 1979. However, daytime sampling can produce an incomplete picture: BOD values indicate that the river and lake are moderately eutrophic and problems could arise on warm still nights when high plant and bacterial oxygen consumption could lead to deoxygenation, perhaps to the extent of asphyxiating fish and invertebrates. To check this, temperature and DO readings were taken at all Stations and in North Lake in the afternoons and at dusk and dawn over 28 – 29 July 1979, two of the warmest days of the year.

TABLE III Temperatures and dissolved oxygen readings taken over twenty-four hours, 28 – 29 July 1979.

(a) *Temperature °C*

Time (hrs)	*North Lake*	*Station U R*	*Station Number* 1	2	3	4	5	6	*Air Temperature*
14.00	20	21	20	21	21	21.5	21.5	21	24.5
21.30	20.5	20.5	19	19	20	20	20	19	19.5
06.30	19.5	19.4	18.5	18	18	18	18.2	18	19
14.00	20	21	20	21	21	21.5	21.5	21	24

(b) *Dissolved oxygen (per cent saturation)*

14.00	133	131	110	113	175	181	147	138
21.30	146	137	78	76	82	138	115	105
06.00	115	117	79	73	69	67	79	67
14.00	130	128	108	112	174	182	145	135

The July 1979 results (Table III) showed the expected pattern of temperature and supersaturation during the day between Stations (maximum 21.5°C and 182 per cent saturation (16ppm of oxygen) at Station 4). The picture was reversed between dusk and dawn to give a minimum temperature and DO of 18°C and 67 per cent (6.6ppm) respectively at Station 4. It is interesting that North Lake and the river below its outfall still remained supersaturated at dawn. Equilibration

with air tends to occur at Station UR (as at Station 5) because of turbulence as water falls over the weir, but North Lake DO was probably maintained by flow through the system of water highly supersaturated during the day. Heal and Bailey (1974) found saturations in July ranging from 104 to 162 per cent. The high daytime DOs at Station 1 may be due to water supersaturated in the Lakes but, on the other hand, large clumps of *Callitriche* and macrophytes were present upstream. Oxygen demand in the river at dusk and overnight was high however, as witnessed by the large fall in DO between Stations UR and 1. This occurred despite the riffle turbulence in this section, backing up the point made above about the oxygen demands.

Overall, it would appear that DO in the study area remains quite high and should generally present no problems to the fish and invertebrates found there. For example, even trout are tolerant, at least for short periods, of oxygen levels down to 5ppm; the lowest level measured was 6.6ppm and very few readings were below 8ppm. The tendency towards supersaturation in the summer months helps compensate for the decrease in oxygen solubility that occurs as water temperature rises.

(iii) pH and alkalinity

The pH was found to be fairly constant and neutral to alkaline and thus was only measured over the September 1978 to July 1979 period; the average pH was 7.5 (range 7.1 – 8.0). There tended to be a slight fall in pH between more riverine to lacustrine stations, probably reflecting greater effects of carbon dioxide in the still waters, arising from plant, animal and, especially, microbial respiration. No abnormal pH levels due to caustic soda or other pollutants were seen.

As might be expected in a chalk stream, the water was hard, alkalinity was high and relatively constant (average 222ppm $CaCO_3$, range 149 – 273).

(iv) Suspended solids

The water was generally clear to the bottom, except during times of high rainfall, and so only one complete set of results was obtained (March 1979). The mean value was 15.9ppm (range 7.8 – 2.85). Values decreased as water currents slowed between Stations 1 to 3, reflecting the deposition of suspended particles. It was noted, however, that the water at Station 2 was very turbid in early 1980 when Lake water levels were high. This was because water flooded and washed sediments from a marshy area of the Lake which has filled-in in the past (shown enclosed by a dotted line in Fig. 1).

Suspended solids were highest when measured at Station 6. This was probably due to some disturbance of sediments during collecting and the larger quantities of very fine, slow-settling sediments found at this most lacustrine of Stations.

(v) Chlorinity

High chloride levels in river water could indicate sewage pollution (i.e. breakdown of urine) or, alternatively, industrial or urban releases of salt. Levels in 36 samples showed chloride was quite low with a mean of 56.9ppm (range 38.7 – 72.2). There was little variation between Stations.

There was, however, at least one period when chlorides were very high below Foots Cray; in isolated samples taken on 30 January 1980, chloride levels at Stations UR, 1 and 4 were 43, 700 and 400ppm respectively. It was suspected that salts were perhaps leaching from road-salt stores in a yard at Foots Cray following heavy rainfall. On more sampling above and below this potential pollutant source

on 7 February (again following rain), very little difference was found. The mean chloride level at six points between Stations UR to 4 was only 40.5ppm (range 26.5 – 58). It is possible that this was a single isolated incident, the origin of which is obscure.

(vi) Heavy metals

Samples of water analysed in October 1978 showed only low levels of iron (mean 0.055ppm, range 0.03 – 0.09), copper (0.02ppm, 0.01 – 0.03) and lead (0.08ppm, 0.05 – 0.10). Levels in single water samples may not reflect average levels over longer periods, but the phenomenon of accumulation of metals by plants can be used to estimate this for a span of one or two days. Concentrations of zinc found in *Callitriche* collected in November 1979 just downstream of Station UR and at Station 1 (i.e. up- and downstream of the industrialized area) were 227 and 276ppm respectively. The corresponding figures for lead were 41 and 58ppm. Both figures show only a slight increase and the levels are not as alarming as might appear. Plants have considerable concentrating powers and the Cray levels are not high when compared with average concentrations of 163ppm zinc and 35ppm lead in plants from rural and unpolluted stretches of the River Roding in Essex (B. McHardy, unpublished results). Thus it can be concluded that, other than via accidents, the study area is probably only minimally polluted by iron, zinc, copper and lead.

The lotic-riverine fauna

It is convenient first to discuss those species more typical of the fast current stations (i.e. UR, 1 and 5 and, to some extent, 2 and 4). They have to be adapted to maintain their position in the current, but are less well adapted to low oxygen and high siltation. In addition, such species would not have been directly affected by dredging of the Lake but might have been much affected by the caustic soda spill.

(i) Porifera. *Ephydatia fluviatilis,* the river sponge, was found as an extensive carpet on the stones at Station UR below Ruxley Lakes, extending along the culvert below the A20. None was found at the main study sites until late summer 1979 on stones and rubble at Station 4. Whether this indicated recolonization following losses due to pollution or dredging is not clear. None was found at Stations 1 and 5, probably because the substratum was generally less stable gravel and small stones.

(ii) Platyhelminths. Only two species of triclad turbellarian were found, *Polycelis nigra* and *Dendrocoelum lacteum,* and then only in very small numbers (eight and one respectively). These were seen at Stations 1 and 5 in August 1979. Such species are tolerant of conditions in both the lotic and lentic regions of the study area and were generally common before the pollution spill (BK, personal observation and Aston and Andrews 1978). The lack of numbers suggests severe mortality due to caustic soda, but only future studies will show if and how populations recover.

(iii) Mollusca : Pulmonata. The river limpet *Ancylus fluviatilis* is well adapted for life in fast rivers. It is not very tolerant of silting because this clogs gills and interferes with grazing of algal films on hard surfaces. Before April 1978, it was fairly common (BK, personal observation, and Aston and Andrews 1978) but was not found in the present study until July 1979 at Station 1. *Ancylus* reproduces in April – May and thus it must be concluded that the population was severely reduced by the caustic soda spill until recolonization from upriver breeding in the spring of 1979. Numbers at Station 1 rose from seven in July 1979 to 41 in December 1979, but then fell back to four in January 1980 following a period of spate.

(iv) Insecta : Trichoptera. Only 43 riverine cased caddis larvae, *Triaenodes* sp. and *Leptocerus* sp., were found in total, eight at Station 1, three at Station 4 and 32 at Station 5. Aston and Andrews (1978) suggest the family Leptoceridae is fairly common in the Cray but none was found until after November 1978, possibly representing recolonization following pollution mortality. This could occur via eggs laid by adults flying from further upriver or by downstream drift of larvae.

TABLE IV Distribution during study of *Hydropsyche* sp. and, in brackets where present, *Philopotamus* sp.

Date	Numbers found at each Station *1*	*2*	*3*	*4*	*5*	*6*	*Total*	*Station U R*
9.9.78	0	0	0	0	0	0	0	—
22.9.78	15	6(3)	3(9)	0	14(11)	0	38(23)	—
18.10.78	24	3(1)	0	2(7)	3(12)	0	32(20)	—
15.11.78	3(3)	0(1)	0	0(4)	2(3)	0	5(11)	—
16.12.78	5	3	0	0(2)	9(4)	0	17(6)	—
8.2.79	12(2)	0(1)	1(2)	0	16(6)	0	29(11)	—
22.3.79	19(1)	4	0	0	44(8)	0	67(9)	—
24.7.79	20	0	0	0	0	0	20	103(4)
31.8.79	16	20	0	0	10	0	46	—
5.11.79	107	3	0	0	17	0	127	645
6.12.79	51	4	0	0	6	0	61	324
4.1.80	32	3	0	0	3	0	38	244
Total	304	46	4	2	124	0	480	
	(6)	(6)	(11)	(13)	(44)	(0)	(80)	

There was a similar lack of the net-spinning and filter-feeding caddis *Philopotamus* sp. and *Hydropsyche* sp. in early September 1978 (Table IV). Numbers then rapidly built up following late summer egg laying and/or by downstream drift. There are certainly large populations of *Hydropsyche* upstream to provide recolonizers. Conditions are ideal here because of the large amounts of fine organic detritus washed from the Lakes. The *Hydropsyche* population at Station 1 showed a remarkable recovery in 1979 compared with 1978. It is unfortunate that no data were collected at Station UR in 1978 to check that this difference was definitely due to pollution and not natural causes. The high numbers (and high proportion of small individuals) into winter 1979 were certainly indicative of a good breeding season and correlated with the mild weather and warm temperatures in early December. The generally smaller numbers at Station 5 possibly indicate delayed recolonization, but on the other hand, only slight changes in flow can lead to exposure of large parts of the gravel bed, rendering this station an unstable environment for such caddis.

The density of *Hydropsyche* and *Philopotamus* populations appears to be inversely related, *Philopotamus* being more plentiful at Station 5 but not appearing at all after spring 1979 (except for four at Station UR in July 1979). This implies that *Hydropsyche* can out-compete the other at the sites studied.

(v) Insecta : Ephemeroptera. Two species of lotic mayflies were found, *Baetis rhodani* and *Ephemerella ignita*. They thrive in fairly clean running water containing much algal and plant debris as food. Stations UR, 1 and 5 were the preferred habitats with a few being washed downstream to Stations 2 and 3. They were never found at Stations 4 or 6 (Table V).

TABLE V Distribution during study of (a) *Baetis rhodani* and (b) *Ephemerella ignita* (only showing months when individuals were found)

(a) *B. rhodani*

Date	1	2	3	4	5	6	Total	Station U R
	Numbers found at each Station							
9.9.78	6	5	0	0	3	0	14	—
22.9.78	51	10	9	0	124	0	194	—
18.10.78	21	0	0	0	0	0	21	—
15.11.78	41	2	0	0	9	0	52	—
16.12.78	4	1	0	0	6	0	11	—
8.2.79	15	1	0	0	8	0	24	—
22.3.79	15	2	0	0	0	0	17	—
24.7.79	160	1	0	0	0	0	161	250
31.8.79	12	4	0	0	8	0	24	—
5.11.79	0	1	0	0	0	0	1	97
6.12.79	0	0	0	0	0	0	0	—
4.1.80	0	2	0	0	0	0	2	0
Total	325	29	9	0	158	0	521	

(b) *E. ignita*

Date	1	2	3	4	5	6	Total	Station U R
24.7.79	312	14	2	0	0	0	328	0
31.8.79	36	5	0	0	4	0	45	—
Total	348	19	2	0	4	0	373	

Table Vb shows that *Ephemerella* has only a very short summer nymphal stage after overwintering in the egg. Thus large numbers were only seen in July, plus some in August, 1979. Whether eggs survived the pollution and produced a full generation in 1978 is unknown because preliminary samples were not taken until September.

Baetis rhodani is fairly tolerant of organic pollution and low DO/high BOD (Hart and Fuller 1974), yet obviously showed a preference for the less silty regions of the river. Eggs hatch throughout the year with autumn and spring peaks. Resistant overwintering eggs or, more likely, summer egg laying probably explain the high numbers of larvae found in November 1978, yet it is difficult to see why population numbers were so much higher at Station 5 than at 1 in that autumn, whilst the reverse was shown the following autumn. Much higher densities were seen in the upriver station in July 1979 than at Station 1. This could perhaps be because numbers peaked at Station 1 at the same time as those for *Ephemerella ignita* and competition resulted.

TABLE VI Distribution during study of *Gammarus pulex*

Date	1	2	3	4	5	6	Total	Station U R
	Numbers found at each Station							
9.9.78	113	46	1	0	50	3	213	—
22.9.78	389	156	8	0	91	11	655	—
18.10.78	239	143	0	4	43	1	430	—
15.11.78	115	74	8	1	71	9	278	—
16.12.78	59	8	7	3	75	0	152	—
8.2.79	191	126	7	2	143	1	470	—
22.3.79	291	223	0	18	252	0	784	—
24.7.79	1060	536	16	104	88	4	1808	1484
31.8.79	2174	1392	2	211	1098	30	4907	—
5.11.79	1096	881	24	167	567	62	2797	1216
6.12.79	1260	562	39	250	892	368	3371	1452
4.1.80	536	378	56	94	346	34	1444	644
Total	7523	4525	168	854	3716	523	17309	

(vi) Crustacea : Amphipoda. *Gammarus pulex* was the most numerous single species found in the study, representing between 35 and 75 per cent of the total number of organisms found at each visit. It is usually more abundant in well-oxygenated, silt-free running water bearing plentiful organic detritus, its main food source (Welton 1979). This is shown to be the case in the Cray, densities being highest at Stations UR and 1 (Table VI). *Callitriche* provided shelter from currents and helped trap detritus at Station 2, but lower current speeds and high predation pressure from the Lake fish probably kept densities below those at Station 1.

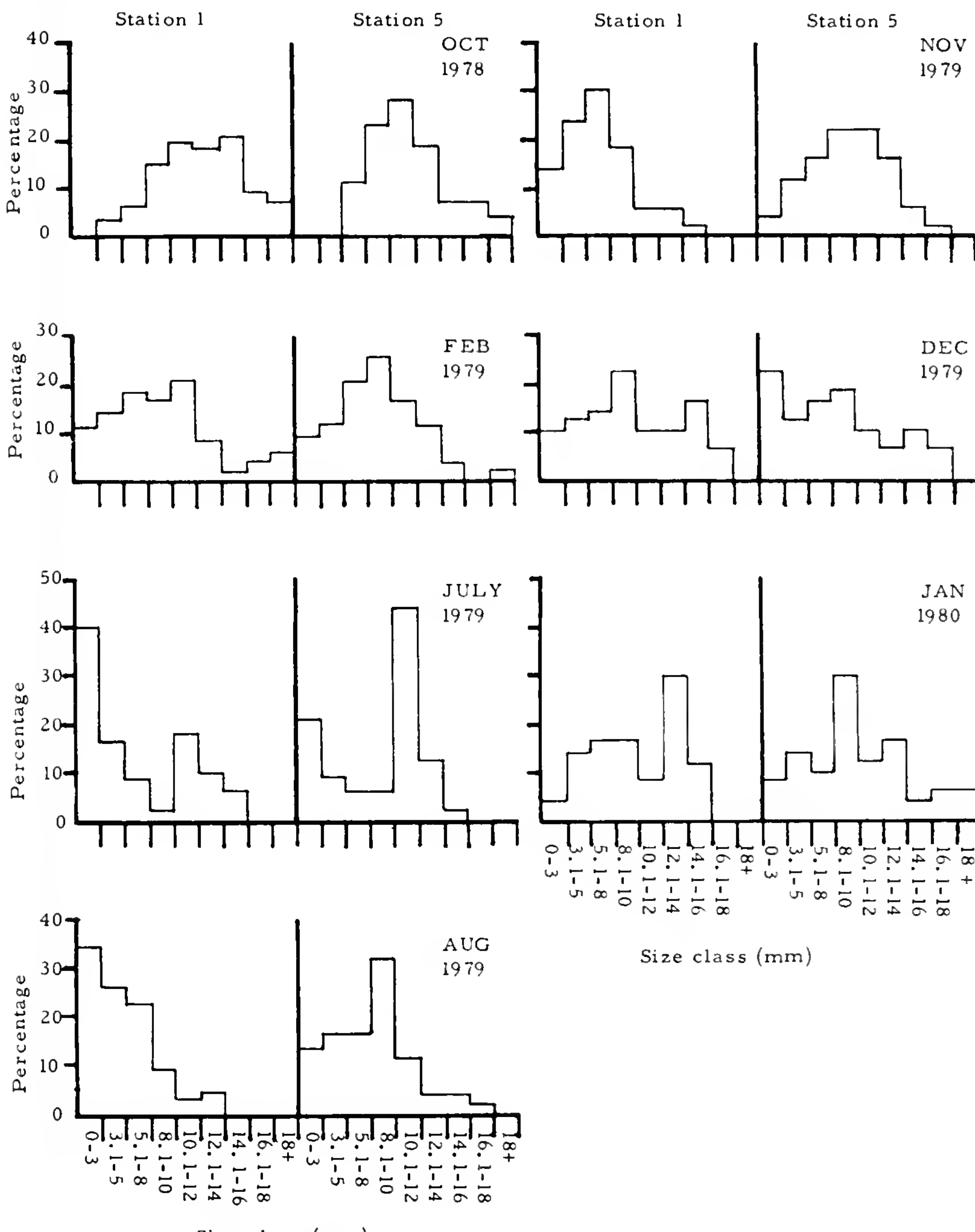

FIG. 2. Size-frequency distribution of *Gammarus pulex* at Stations 1 and 5 (showing percentages of a random sample falling into different body-length groups).

Densities increased in late summer and autumn as a result of a summer reproductive peak and fell in late winter – early spring (mainly due to mortality of large individuals, see Fig. 2). These results are similar to those for *Gammarus* in Tadnoll Brook, a Dorset chalk stream (Welton 1979). Densities were much higher in 1979, however, suggesting a severe mortality from the caustic soda pollution in April 1978. Size-frequency data for October 1978 (Fig. 2) show a marked scarcity of immature individuals (i.e. less than 6 – 8mm in length, Welton 1979). This suggests that breeding was much reduced in the summer and autumn of 1978. Individuals found tended to be larger mature specimens which had probably already bred and drifted downriver from above the point of the caustic soda discharge. In 1979 – 80, the upriver station supported large *Gammarus* populations and it is probable these were present in the previous year to provide recolonizers. The size-frequency data for February 1979 indicates that the caustic soda would not only have killed egg-bearing females but also any immature individuals already produced in spring 1978. Although reproduction may occur at a low level throughout the year, full recovery was delayed until the reproductive peak of the overwintering recolonizers in the spring and summer of 1979. A more normal reproductive cycle was seen in the second half of 1979 with high proportions of smaller mature individuals produced in the spring and of recently hatched immatures. Peak reproduction appeared to occur in July with a gradual increase in the mean size of individuals between July and November. High densities in December 1979 reflect the mild weather in that month. Densities were still relatively high in January 1980 and the high proportions of small individuals indicate continued breeding. Larger individuals appear to be relatively more numerous at Station 1 than at UR, possibly because large individuals are more easily washed downriver.

The delay in recovery of *Gammarus* in 1978 could have been important in relation to the fishery at Five Arches as they are probably a major food source. Many *Gammarus* drift from the river into the lake and fish tend to congregate as it opens out at Station 2. Therefore, it appears that the toxic spillage had severe effects on the *Gammarus* population. However, had the pollution affected the whole of the river below Ruxley Lakes, the effect would have caused far more damage by removing the source of recolonizers, hence greatly prolonging recovery time.

The fauna of the lentic-lacustrine regions

Whilst some of the species discussed in this section are often common in streams, they are more typical of slow-moving stretches of rivers and are found in lakes. In the present study they were predominant in Five Arches Lake. These species are also worth discussing together because they would have been affected by the dredging as well as the caustic soda in 1978.

(i) Annelida : Oligochaeta. These were represented by *Tubifex*, *Lumbriculus* and *Nais* species and *Limnodrilus hoffmeisteri* and *Eiseniella tetraedra*. None was found in the densities that would be expected in waters suffering from continuous gross organic enrichment (Table VII).

Tubificids normally burrow and ingest bacteria. They are very tolerant of low oxygen levels but were not common even at the most lacustrine of Stations. In comparison, in Regent's Park Lake tubificids are abundant. Numbers may have been reduced by dredging and pollution but the build-up in autumn and winter of 1978 was repeated late in 1979 following the appearance of high densities of naids. This coincided with leaf-fall and increases in detritus and bacteria at all Stations, conditions being particularly ideal during the warm December of 1979. In January 1980, a spate had removed much of the dead leaf cover at Station 3, exposing bare mud and encouraging a locally dense *Tubifex* population. The

TABLE VII Distribution during study of oligochaete annelids.
(Naids were impossible to count and relative densities are shown as (p) present, (c) common, (a) abundant. No oligochaetes were found at Station UR).

Date	*Numbers found at each Station* *1*	*2*	*3*	*4*	*5*	*6*	*Total*
9.9.78	0	4	10	0	0	5	19
22.9.78	0	44	12	4	6	23	89
18.10.78	2	51	27	15	0	17	112
15.11.78	3	41	13	11	1	5	74
16.12.78	0	12	14	0	0	28	54
8.2.79	0	17	21	3	0	19	60
22.3.79	2	45	31	12	2	35	127
24.7.79	0	2	2	0	0	0	4
31.8.79	0	115	656	0	23	2(c)	796
5.11.79	0	0(p)	0(a)	0	0	0(c)	0
6.12.79	49	19(c)	0(a)	0(c)	0	324(c)	392
4.1.80	0	0(c)	954	0(p)	0	0(c)	954
Total	56	350	1740	45	32	458	2681

lower numbers during the middle of 1979 were probably due to competition with chironomid larvae and predation by leeches. Inverse relationships between densities of tubificids and these species were observed (see further discussion below).

Limnodrilus hoffmeisteri is commonly associated with *Tubifex* and showed a similar pattern of distribution and density, but only in 1978. It, like *Tubifex* to some extent, favoured Stations 2 and 3, i.e. the sites of entry of sediments brought down by the river.

Lumbriculids were absent until 1979 and then only showed a short-lived and local build-up at Stations 2 and 3 in July – August 1979 (numbers found in August were 115 and 656 at these Stations respectively).

Only four *Eiseniella tetraedra* were found at various Stations and times, hence little can be said about them except that they are common according to Aston and Andrews (1978). The distribution of naids was more like that of the lumbriculids, however, showing a large build-up at Stations 2 and 3 and, to a smaller extent, at Station 6 in autumn 1979. Only relative densities could be estimated because they tended to form tangled masses of long fragile chains of asexually reproducing individuals. Unlike the tubificids, they were common where there were layers of decaying leaves, especially at Station 6.

Without further long term studies, it is not possible to reach firm conclusions about the changes in oligochaete density and distribution and the effects of pollution and dredging. The latter may give the best explanation for the relatively low densities in 1978; dredging would have removed organic sediments which were only replenished later by riverborne material, die-back of algae and autumn leaf-fall. Competition with chironomid larvae and predation by fish and leeches might also be important, especially with regards to explaining low numbers and diversity in mid-1979.

(ii) Annelida : Hirudinea. Only one specimen each of the parasitic species *Theromyzon tessulatum*, *Piscicola geometra* and *Hemiclepsis marginata* were found. The first is a parasite of wildfowl, the other two are fish parasites. Carnivorous leeches were better represented (Table VIII), as might be expected, with *Erpobdella octoculata* and *Glossiphonia complanata* predominating. Only one *Glossiphonia heteroclita* was found in November 1979, outside the Lake at

Station 5. This species was fairly common in the Cray according to Aston and Andrews (1978) and thus it may have been badly affected by the pollution and/or dredging.

TABLE VIII Distribution during study of carnivorous leeches.

	Numbers found at each Station							Station
Date	*1*	*2*	*3*	*4*	*5*	*6*	*Total*	*U R*
9.9.78	0	5	0	0	0	1	6	—
22.9.78	0	16	0	4	26	4	50	—
18.10.78	2	14	0	6	3	0	25	—
15.11.78	7	17	0	1	6	0	31	—
16.12.78	1	3	2	0	1	5	12	—
8.2.79	0	5	0	0	5	4	14	—
22.3.79	6	6	0	11	16	0	39	—
24.7.79	0	4	2	14	12	4	36	1
31.8.79	4	27	2	14	29	2	78	—
5.11.79	9	14	3	11	6	11	54	0
6.12.79	11	11	22	18	6	0	68	0
4.1.80	2	9	20	7	3	0	41	0
Total	42	131	51	86	113	31	454	

Sixty-six *Helobdella stagnalis* were found, mainly at Stations 2 and 6, and they were more common in late 1978 and 1979 which tends to reflect their preference for feeding on tubificids and related oligochaetes which were more common at these times (as discussed above). They are tolerant of organic enrichment and low oxygen and the 'clean' conditions in the Lake and relative paucity of oligochaetes help explain the relatively low densities in relation to other leech species. The effects of the pollution and dredging are debatable, but leeches are quite mobile and many would have been expected to have avoided the dredge. In this case, differences in recovery may be related to resistance of egg capsules to caustic soda in 1978 and then competition in 1979. Species which showed much the same numbers in 1978 and 1979 were depositing possibly resistant horny egg capsules at the time of the spillage; over-wintering *Helobdella stagnalis* breed and deposit capsules in the spring, as does *Glossiphonia complanata* (during April – May by one-year-olds and March by two-year-olds). *G. complanata* was almost as numerous overall as *Erpobdella octoculata* yet the latter did not really build up in numbers until late summer – early autumn 1979, despite its preference for oligochaetes and insect larvae. *E. octoculata* does not deposit capsules until the summer and autumn with emergence in autumn and early winter, and thus could have suffered a more severe depletion due to adult mortality from the April 1978 spillage. There were in fact many capsules found attached to stones into the winter of 1979/80, correlating with the mild weather and the appearance of large numbers of small *E. octoculata*.

These conclusions are tentative but it will be interesting to see how the species fare in the future, especially in relation to preferred diet (e.g. *G. complanata* prefers snails and might be expected to increase as prey numbers build up) and possible inter- and intraspecific competition. In relation to diet, it seems strange that leeches predominated at Stations 2, 4 and 5 whilst prey species (oligochaetes, chironomids and molluscs) were most plentiful at Stations 3 and 6. This probably represents a compromise between food availability and the fact that Stations 3 and 6 are areas of high siltation and settlement of organic debris; leeches prefer firmer substrata for sucker attachment and locomotion. Current speed was, however, too high and no prey species were present at Station UR; only one *G. complanata* was found and this had possibly been washed out of Ruxley Lakes.

(iii) Insecta : Diptera. Forty-three tupulid larvae were found in total at Stations 1, 2 and 3 in September – October 1978 and three at 1 in December 1979. These are not very common in rivers and were probably derived from soil-living individuals disturbed by bank erosion upstream and, in autumn 1978, tree cutting operations on the banks just upstream of Station 2 (only two of the specimens were found at Station 1 at this time).

TABLE IX Distribution during study of chironomid larvae.

Date	Numbers found at each Station *1*	*2*	*3*	*4*	*5*	*6*	*Total*	*Station U R*
9.9.78	0	2	0	0	3	0	5	—
22.9.78	11	4	4	0	50	4	73	—
18.10.78	6	4	4	0	15	0	29	—
15.11.78	7	3	2	0	7	10	29	—
16.12.78	1	0	3	0	0	0	4	—
8.2.79	0	7	9	0	13	15	44	—
22.3.79	10	44	17	18	22	4	115	—
24.7.79	0	5	0	3	0	1	9	3
31.8.79	12	14	6	5	1	27	65	—
5.11.79	0	0	25	4	0	10	39	1
6.12.79	0	0	54	3	1	24	82	0
4.1.80	0	6	126	2	0	4	138	0
Total	47	89	250	35	112	99	632	

Chironomid larvae were much more common and ubiquitous (see Table IX). They are detritivores and very tolerant of stagnant conditions and anaerobic muds, especially the 'red' larvae which possess haemoglobin. The 'clean' post-dredging conditions in Five Arches Lake did not favour the latter species and they represented only 8.7 per cent of the total numbers of chironomids found up to November 1979. As anaerobic sediments accumulated, red chironomids increased to 39 per cent of the total in December 1979 – January 1980. The numbers of colourless chironomids also followed the build-up of organic sediments, especially at Station 3. Densities at Station 5 were sometimes relatively high, probably due to individuals being washed out of Five Arches Lake.

(iv) Insecta : Trichoptera, Ephemeroptera and Odonata. Cased caddis larvae were quite scarce, 19 *Triaenodes*, 24 Leptoceridae and one large *Phryganea grandis* being found at various times and Stations (except Station 6) after November 1978. Whether populations were affected by pollution and/or dredging earlier in the year is difficult to say because other than the Leptoceridae, such species were not found to be common by Aston and Andrews (1978) or Bailey (1973). These authors reported lentic-lacustrine Ephemeroptera such as *Cloeon dipterum*, and Odonata such as the Coenagriidae to be quite common but none was found during the study period. Coenagriidae were observed, however, in non-quantitative sampling in the River and Lake in February 1980.

(v) Insecta : Coleoptera. *Haliplus ruficollis* and *Limnius volckmari* larvae were found, plus adults of the former but not until July 1979. These larvae are still-water species and the majority were found at Stations 3, 4 and 6. *Haliplus* larvae feed on filamentous algae and were associated with heavy blankets of *Cladophora* in August – November 1979. Haliplid beetles are found in the Cray (Aston and Andrews 1978) and Ruxley Lakes (Bailey 1973). Whether there was an indigenous population which was affected by pollution and/or dredging in 1978 is not known. Recolonization by flying adults might easily have occurred were this the case.

The same applies to the other species, *Limnius volckmari*. This species was only found by Aston and Andrews (1978) in the River Darent, however, and its appearance in 1979 suggests a new colonization. Twenty-seven larvae were found in late summer and autumn 1979 (compared with a total of 59 *Haliplus* larvae and 10 adults).

(vi) Insecta : Hemiptera. Fifty-three *Sigara* nymphs and adults were found, those identified fully being *S. falleni*. *Sigara* are still-water suctorial detritivores and hence were most common at the lacustrine Stations 4 and 6. Interestingly, by far the largest number in a single collection (i.e. 28) was at Station 6 in early September 1978. They are occasional to common in Ruxley Lakes, were found in drift from these Lakes (Table XV) and the adults can fly. Whether non-flying nymphs of this and other species were present in early 1978 is unknown.

TABLE X Distribution during study of *Asellus aquaticus*.

Date	Numbers found at each Station 1	2	3	4	5	6	Total	Station U R
9.9.78	0	10	0	0	2	4	16	—
22.9.78	17	13	0	3	31	0	64	—
18.10.78	12	27	0	14	2	0	55	—
15.11.78	11	19	3	5	14	4	56	—
16.12.78	0	0	0	0	10	0	10	—
8.2.79	3	5	0	3	39	0	50	—
22.3.79	16	11	1	14	32	0	74	—
24.7.79	5	1	10	15	0	0	31	0
31.8.79	16	9	0	47	11	1	84	—
5.11.79	8	1	0	83	23	15	130	5
6.12.79	1	2	4	69	36	68	180	3
4.1.80	1	2	2	11	26	16	58	0
Total	90	100	20	264	226	108	808	

(vii) Crustacea : Isopoda. *Asellus aquaticus* is a scavenger/detritivore typical of organically enriched waters and the 'clean' condition of Five Arches after dredging probably accounts for its relatively low numbers (Table X). The maximum density was about $80-90m^{-2}$ (Station 4, November 1979) which compares with a range of mean densities of $67-586m^{-2}$ in 1973–4 in Wistow Lake near Leicester (Adcock 1979). Population densities were much higher in late 1979 than in late 1978. Reproduction occurs mainly in February – June and July – September. The first reproduction in 1978 might have been severely affected by the spring pollution spill and the dredging. However, some individuals probably survived to reproduce in the autumn. The relatively large numbers at Station 1 also suggest downstream recolonization from unaffected regions. Very few were found at the upriver Station or in the drift from Ruxley Lakes, but they might be common in more still and vegetated sections of the river. The relatively high numbers found in various months at Station 5 are difficult to match with this suggestion and more studies are necessary to clarify these points.

(viii) Arachnida. Only six hydrachnellid water mites were found at Station 6 in December 1979, though they were reasonably frequent according to Bailey (1973) and Aston and Andrews (1978).

(ix) Mollusca : Gastropoda. Of the prosobranchs, only one *Valvata piscinalis* was found (at Station 1 in October 1978), *Potamopyrgus jenkinsi* was fairly common, however, being found mainly at Station 2 with numbers increasing in autumn 1978 and to a larger extent in 1979 (Table XI). Overwintering adults reproduce in midsummer and then die and the progeny can often grow rapidly enough to release young during the autumn and winter. This would explain the

peaks in density observed with a reduction in 1978 due to pollution and/or dredging. Numbers were low at the end of the study.

TABLE XI Distribution during study of common species of gastropod molluscs (Single or very infrequent records for other species are not shown — see text for further discussion).

(a) *Total numbers at Station No.*	*Lymnaea peregra*	*L. stagnalis*	*L. auricularia*	*Planorbis* spp.	*Physa heterostropha*	*Potamopyrgus jenkinsi*	*Total*
1	8	0	0	16	0	8	32
2	35	3	2	16	9	110	175
3	153	10	9	48	5	15	240
4	80	3	4	6	0	6	99
5	78	3	10	18	0	0	109
6	1500	18	12	42	9	51	1632
Total	1854	37	37	146	23	190	2287

(b) *Date*	*Lymnaea peregra*	*L. stagnalis*	*L. auricularia*	*Planorbis* spp.	*Physa heterostropha*	*Potamopyrgus jenkinsi*	*Total*
9.9.78	43	0	0	9	2	5	59
22.9.78	32	0	8	18	2	6	66
18.10.78	30	3	8	14	1	32	88
15.11.78	41	5	13	7	0	4	70
16.12.78	81	8	4	22	3	11	129
8.2.79	68	2	2	29	3	23	127
22.3.79	67	0	2	13	8	9	99
24.7.79	194	3	0	7	0	47	251
31.8.79	130	5	0	1	4	52	192
5.11.79	377	2	0	8	0	1	388
6.12.79	679	5	0	18	0	0	702
4.1.80	112	4	0	0	0	0	116
Total	1854	37	37	146	23	190	2287

The pulmonate gastropods are more typical of lentic eutrophic hard waters, being hermaphroditic, annual reproducers and capable of breathing air. They were well represented in Five Arches Lake, especially at Station 6, but were relatively scarce at Stations 1 and UR (33 being found at the latter). The lymnaeids were dominant (Table XI) though *L. stagnalis* and *L. auricularia* were much less common than *L. peregra. L. auricularia* was not seen after July 1979 and only one *L. palustris* was found. Numbers were relatively stable in late summer – early autumn 1978, suggesting downstream recolonization or, more likely, a residual local population that survived the pollution (e.g. by climbing out of the water) and avoided the dredge (e.g. among the vegetation on the islands). *L. peregra* showed a marked recovery in late 1979, especially amongst dead leaves at Station 6, whereas *L. auricularia* showed a decline. Whether this was due to competition or changes in habitat is not clear.

Planorbids were less common than lymnaeids with *P. albus* predominating over *P. leucostoma* and *P. planorbis*. Physids were uncommon; a few *Physa heterostropha* were found and only one *Physa fontinalis*.

All the above species were found by Bailey (1973) and/or Aston and Andrews (1978) except for *Lymnaea auricularia, Planorbis leucostoma* and *Physa heterostropha*. The former was identified in the River Wandle, however, by McCrow (1974).

TABLE XII Distribution during study of bivalve molluscs *Sphaerium* and *Pisidium* spp.

Date	*Numbers found at each Station* 1	2	3	4	5	6	*Total*	*Station* U R
9.9.78	34	9	3	0	8	13	67	—
22.9.78	7	1	0	0	3	4	15	—
18.10.78	30	22	1	0	1	3	57	—
15.11.78	45	11	1	0	0	8	65	—
16.12.78	3	0	11	1	0	11	26	—
8.2.79	33	2	10	4	0	6	55	—
22.3.79	68	30	8	5	0	5	116	—
24.7.79	44	59	72	14	23	43	255	11
31.8.79	92	30	28	96	0	48	294	—
5.11.79	14	3	211	206	0	106	540	26
6.12.79	13	7	85	116	7	221	449	9
4.1.80	0	6	0	45	41	224	316	24
Total	383	180	430	487	83	692	2255	

(x) Mollusca : Bivalvia. *Sphaerium* and *Pisidium* spp. were very sparse in 1978, except at Station 1 and, to some extent, at 2 (Table XII). Whether these individuals represent survivors of the caustic soda spill or ones washed downstream is not clear. The low numbers at the more lentic-lacustrine Stations suggest losses due to pollution and/or dredging. These species, especially *Pisidium,* are fairly tolerant of pollution and being hermaphroditic, ovoviparous and even self-fertilizing, population numbers can increase rapidly when conditions are favourable. The marked increase in densities at Stations 3, 4 and 6 in late 1979 probably mirrored the build-up of organic sediments and debris, as might be expected of such filter-feeding bivalves. *Pisidium* being smaller tended to dominate, especially amongst decaying leaves at the more lentic-lacustrine Stations. Numbers were low at Stations 1, 2 and 3 in January 1980, probably due to individuals being washed into deeper parts of the Lake by the preceding period of spate.

Pisidium are generally common in London's rivers (Aston and Andrews 1979) and both they and *Sphaerium* are common in Ruxley Lakes (Bailey 1973).

Recovery of macroinvertebrates and biological indices

Having considered physico-chemical parameters and different animal groups in depth, it is important to consider the overall recovery of species and individuals and what they indicate about diversity, community structure and pollution. Fig. 3 shows that the number of species or genera in the riverine part of the study area (Stations 1, 2 and 5 combined) was fairly high at the beginning of the study. This indicates that recolonization after the April pollution was well advanced, though further new species (e.g. *Ephemerella ignita* and the Coleoptera) were present at about the same time of year in 1979. This recolonization probably occurred mainly via drift and flight of adults from other parts of the river system as discussed previously. The number of species at the more lentic-lacustrine Stations 3, 4 and 6 was fairly low initially but recovered in the autumn. The build-up of sediments and leaf-fall in late autumn 1980 correlated with the appearance of a few extra species, largely oligochaetes.

In both parts of the study area, total numbers of individuals initially appeared low. There was a small recovery in the riverine sections in early autumn 1978 following late summer breeding, but full recovery was delayed until the same period in 1979. The recovery at the more lacustrine Stations was delayed for a whole year, reflecting the delayed build-up of organic detritus and sediments and slower dispersion of the Lake species after late summer breeding. Another factor not considered so far is that the fish introduced in 1978 could have exerted strong

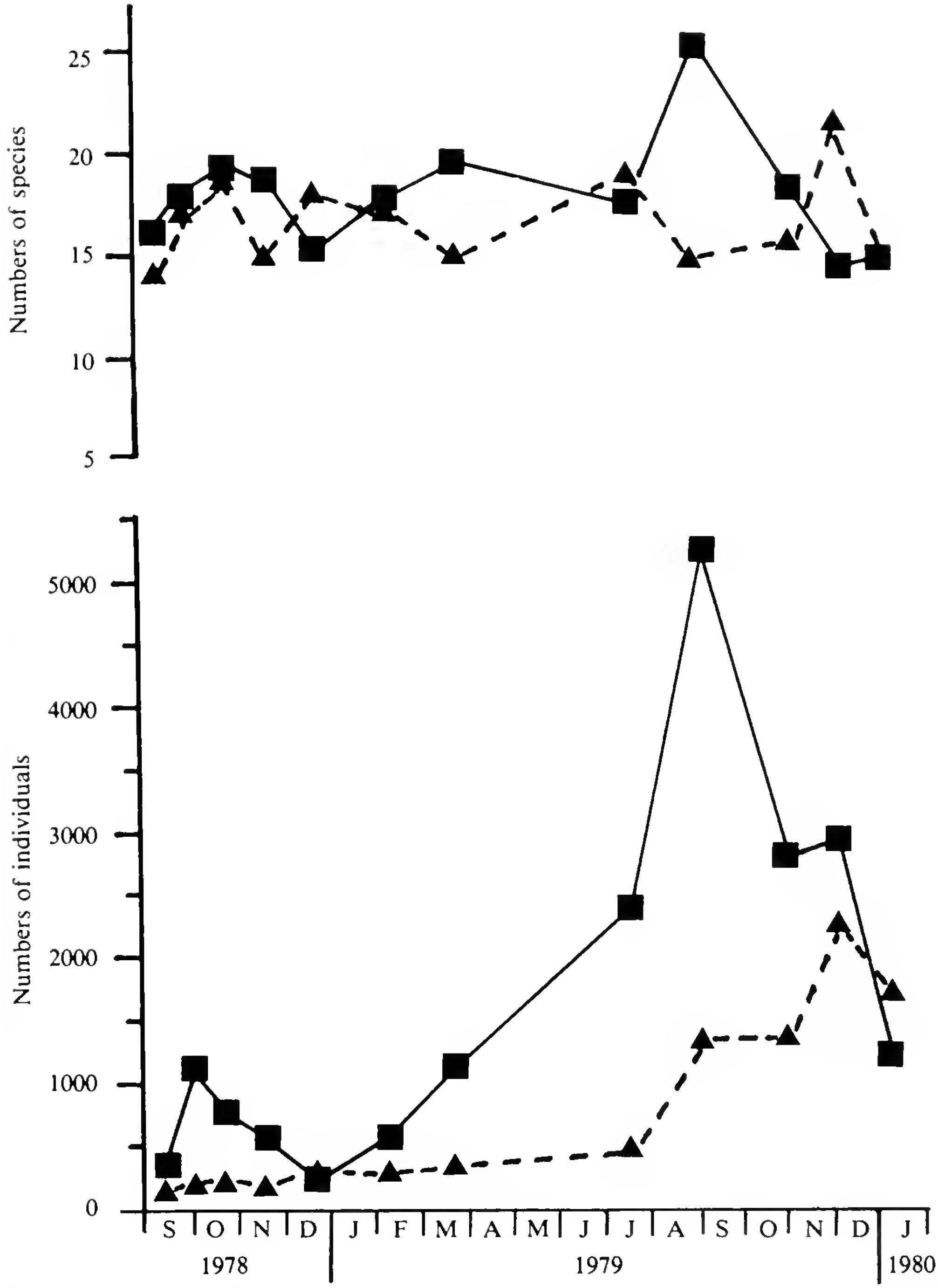

FIG. 3. Graph showing changes in numbers of species (upper section) and total number of individuals (lower section) collected each month. Squares indicate combined data for riverine Stations 1, 2 and 5, triangles indicate combined data for lentic-lacustrine Stations 3, 4 and 6.

enough predation pressures to delay recovery. This is unlikely to have been a major factor, however, if the data are compared with that for recovery of a muddy reach of a mill stream in southern England after dredging (Crisp and Gledhill 1970). These authors also found, in the absence of fish stocking, that

recovery took a year. Even after two years, Oligochaeta and triclads were still building up.

The recovery in the Cray involved changes in species dominance and community structure which can be assessed by the use of various biological indices. These are also useful in assessing the effects of chronic low or fluctuating levels of pollutants which are inadequately detected by spot sampling. This is because environmental stress, such as that due to pollution, tends to lower diversity, i.e. only the most resistant 'indicator' species can survive and flourish, the least resistant are eliminated or are very sparse. Biological indices have been developed to relate numbers of individual benthic macroinvertebrates in rivers to numbers of groups present. Such indices are, however, open to some criticism because they could indicate pollution stress as such or simply that natural environmental factors are acting so as to encourage one or a few animal groups at the expense of others. Occasional drift of non-indigenous species and the presence or absence of ephemeral ones can also produce aberrant results.

The Trent Biotic Index (Woodiwiss 1964) is one which has been much used, although its sensitivity is limited. It is based on scoring the environment on the presence/absence of key macroinvertebrates groups and the total number of other key groups present. For example, the presence of Plecoptera nymphs plus many other species indicates very good quality water. Scores from one to ten are obtained with five to six indicating a river of satisfactory quality with little pollution. Lower scores are supposed to indicate progressively poorer quality and higher pollution stress. One drawback of this index is that it was devised to compare riffle areas of rivers and so cannot be applied to Stations 3, 4 and 6 in the present study. To overcome this problem when studying Ruxley Lakes, Heal and Bailey (1974) drew up a Modified Trent Biotic Index which excluded purely riverine groups like the Plecoptera and placed more emphasis on lacustrine ones such as the Hirudinea, Coleoptera and Hemiptera. The data in the present study were analysed using the Modified Index for the more lacustrine Stations and the unmodified one for the others. The average value over the study for the former was five and for the latter, six, indicating only mild pollution. These compare with figures of seven to eight for the lower Cray just upstream of the tideway (Aston *et al.* 1979). There was little variation over the course of study except for a few instances due to natural causes. For example, low scores of four and five at Station 1 occurred during spate whilst the lowest at Station 5 (four) occurred during a dry spell when much gravel was exposed and dry. In addition, the presence or absence of just one species was found to produce differences, e.g. the short-lived appearance of *Philopotamus* and *Ephemerella ignita* improved some scores relative to others. That the study area only suffered mild pollution and that the Index only gave approximations of true pollution status is shown by the fact that values for the unpolluted Station UR also ranged from seven in summer to four in winter.

More sophisticated biological indices are supposed to be less prone to distortions; the Chandler Score, for example, incorporates relative abundance of key groups (Chandler 1970) such that points are accumulated to give a whole figure score. Combined data for the riverine and more lacustrine Stations gave average values over the whole study of 325 and 260 respectively. Fluctuations occurred between a minimum of 124 (Station 1, January 1980) and a maximum of 489 (Station 2, September 1978) but it was difficult to relate these to any pollution effects. They appeared to relate more to natural environmental changes such as spate and winter die-back and to summer reproductive and hatching times. Comparable values were certainly shown at the unpolluted Station UR where the score fell from 322 in summer 1979 to 121 in the winter. This also indicates that the River and Lake suffered little from pollution.

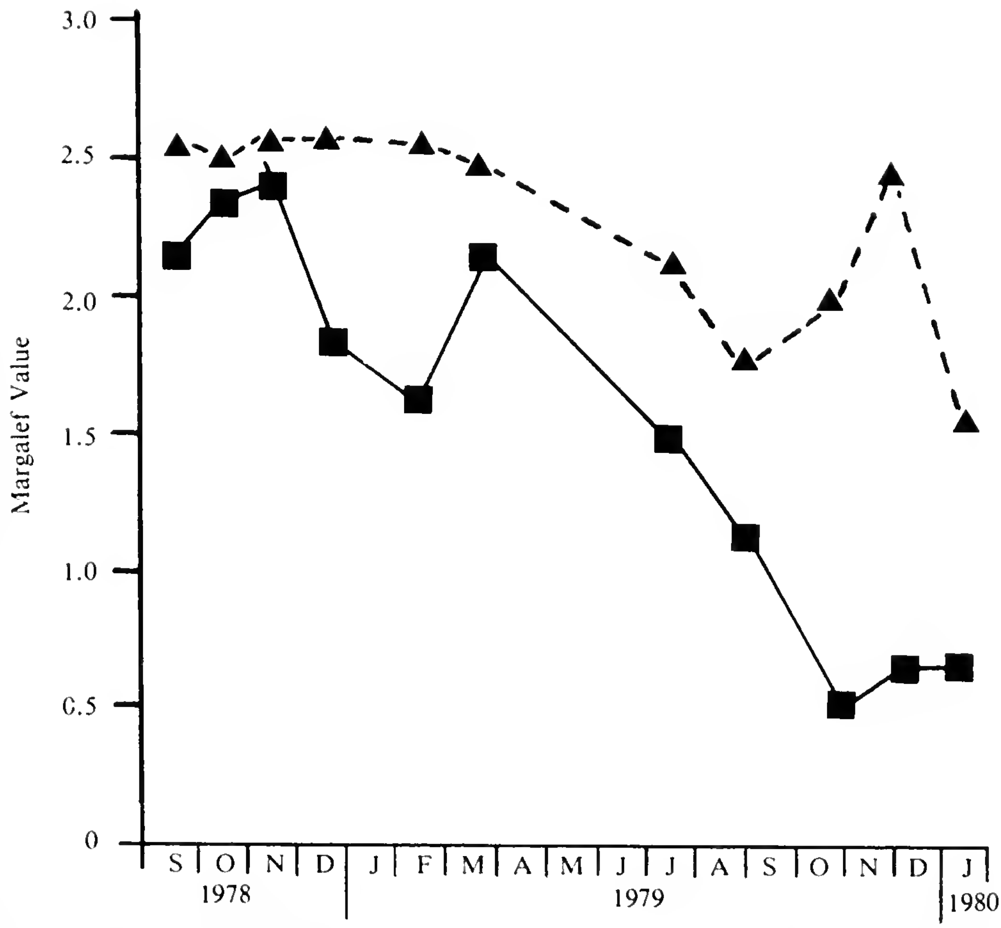

FIG. 4. Changes in Margalef Diversity Index values over the course of the study (Symbols as in Fig. 3.).

Another index commonly used is the Margalef Diversity Index. This compares numbers of groups present (t), numbers of individuals in each group (n_i) and total number of individuals in a whole sample (N) thus:-

$$\text{Margalef D. I.} \;=\; -\Sigma \frac{t\ n_i}{N} \log_2 \frac{t\ n_i}{N}$$

Values below 1.5 are generally accepted to represent low diversity due to high pollution stress whilst values between 1.5 – 3 indicate intermediate levels. Combined values for riverine *versus* more lacustrine Stations are shown in Fig. 4. The results would appear to show that pollution effects were mild to start with but tended to increase and eventually became severe, particularly in the River. This, however, is probably an erroneous conclusion since the unpolluted Station UR had summer D. I. values of about one, falling to 0.7 in winter 1980. Again, the explanation is that the figures probably indicate natural changes that would be expected in the recovery process. Thus, there was no marked paucity of species, even at the beginning of the study, but as breeding recovery occurred, so certain species came to dominate (e.g. *Gammarus* and *Hydropsyche* in the River, *Lymnaea peregra* and the Bivalvia and Oligochaeta in the Lake). This dominance was probably due to differences in current speed and substrata in the two habitat types, encouraged by the naturally eutrophic status of the Cray. The falls in

Diversity Indices at riverine Stations over each winter reflect natural winter die-back of populations and lack of summer ephemerals such as the Ephemeroptera. The increases at Five Arches Lake in late autumn – early winter 1979 are largely explained by the appearance and/or resurgence of various oligochaete species and leech predators, which again correlate with accumulation of sediments and leaf-fall.

The data and indices overall suggest that the study area was not affected much by industrial pollution although it is fairly eutrophic which encourages better adapted species at the expense of others. Furthermore, comparison of index values with those for unpolluted Station UR suggest that a natural balance between types and densities of competing species and predators and prey was being reached by the end of the study.

TABLE XIII Drift of organisms from Ruxley Lakes into the River Cray: numbers caught in a net sampling one-fifteenth of the total outflow.

	30–31 August 1979			*22–23 November 1979*		
Invertebrates	*Daylight (15.5 hrs)*	*Nightime (8.5 hrs)*	*Total*	*Daylight (9.5 hrs)*	*Nightime (14.4 hrs)*	*Total*
Gammarus pulex	11	31	42	16	81	97
Baetis rhodani	38	10	48	0	0	0
Hydropsyche sp.	4	3	7	1	5	6
Sigara falleni	0	4	4	3	6	9
Asellus aquaticus	1	0	1	2	0	2
Eiseniella tetraedra	0	1	1	0	0	0
Piscicola geometra	0	1	1	0	0	0
Chironomid larvae	0	0	0	5	0	5
Lymnaea peregra	0	0	0	1	0	1
Notonecta glauca	0	0	0	0	1	1
Totals	54	50	104	28	93	121
Fish						
Leuciscus leuciscus (fry)	0	137	137	0	0	0
Abramis brama (fry)	0	0	0	0	10	10
Leuciscus cephalus (fry)	0	0	0	0	3	3
Gasterosteus aculeatus	0	0	0	0	1	1
Pungitius pungitius	0	1	1	0	1	1
Totals	0	138	138	0	15	15

Recolonization of the river from Ruxley Lakes

Relatively few animals were washed out of the Lakes, bearing in mind their extent, the rate of flow of water from them and the length of sampling periods (Table XIII). *Gammarus pulex* were caught in the largest numbers, especially over the hours of darkness, since they become more active, swim upwards and are swept along in currents mainly after sunset when daylength is long; a secondary peak in activity occurs just before dawn when daylength is shorter, helping to explain the larger numbers caught in November 1979. *Baetis rhodani*, on the other hand, shows peaks just after dawn, hence the larger daylight catch in August 1979 (none was caught in November 1979, although there were high numbers at Station UR). No other invertebrate species was as numerous and thus it can be concluded that Ruxley Lakes are not a very important source of recolonizers. The water is quite deep above the weir and as the fauna is largely lacustrine and inactive, few animals would be caught in the surface current and washed out.

Fish were also found in apparently low numbers except for 137 dace fry. This catch probably represents one or a few schools of fry. Schools of other species may have been missed and it is difficult to assess by such a method just how important the Lakes are as a source of fish recolonizers.

The zoo- and phytoplankton

Microscopic plankton are uncommon in lotic environments. This was borne out by observations in Five Arches; firstly, overall densities of apparently live specimens were very low. For example, the maximum density of *Bosmina longirostris* was 49 per 20-litre sample. (Station 3, August 1979). In the same sample were nine *Cyclops* sp. and a few of the green alga *Ankistrodesmus* sp. In contrast to this, phytoplankton can easily exceed 50,000 cells per cm^3 and zooplankton 100,000 cells per cm^3 in August in a truly still lake such as that in Regent's Park (A. N. Sutcliffe, unpublished results).

TABLE XIV List of plankton species found in the study area (given in order of relative overall abundance).

Phytoplankton species:	*Spirogyra, Volvox, Asterionella, Scenedesmus, Gloeotrichia, Ankistrodesmus.*
Zooplankton species:	*Cyclops, Bosmina longirostris, Brachionus,* Ostracoda, *Chydorus, Diaptomus, Daphnia hyalina.*

At Five Arches, density and diversity were lowest at Stations 1 and 5 but increased as currents slowed at 2, 3, 4 and 6. It is probable that most of the individuals found had been washed downstream from Ruxley Lakes where they are common (Bailey 1973). They were only able to slow but not halt their passage through Five Arches, tending to accumulate at Station 4 before being washed out. Because of this, no attempt has been made to represent abundances quantitatively, but a list of species is given in Table XIV. The most numerous zooplankton (mainly in late summer) were the water flea *Bosmina longirostris* and *Cyclops* sp. Being small and mobile, they were possibly more able to maintain position in the currents and avoid predation by fish for longer in Five Arches Lake.

The most abundant phytoplankton was *Spirogyra* sp. Being a filamentous alga, it entangles with vegetation and other obstructions, helping to reduce washout. However, phytoplankton density was generally very low, providing little food for zooplankton which in turn, provided a negligible food supply for fry, small juvenile fish or adult sticklebacks.

Fishes

The present study was not designed to look at fish species and populations but some were caught during sampling and are worth commenting upon. Sticklebacks were ubiquitous and numerous (158 *Gasterosteus aculeatus,* three-spined stickleback and 158 *Pungitius pungitius,* ten-spined stickleback). These were most common following hatching in late summer in 1979, especially at Station 2. Few were caught in 1978, suggesting a high mortality, along with other species, due to the caustic soda spill. Recolonization probably occurred from upriver and Ruxley Lakes.

Other species caught were 11 fry of chub and 39 of dace and 12 adult minnows. Chub was not present in Ruxley Lakes (Bailey 1973) but was one of the species introduced by TWA in 1978. The presence of fry possibly indicates some breeding success.

The Thames Water Authority carried out a fisheries survey along the whole River Cray in November – December 1979 (J. T. Percival and S. King, unpublished results) and this showed that fish stocks were generally very good. Results at Five Arches, however, showed a fall in the original restocking density from 20g m^{-2} to 11.79g m^{-2}. This suggests high losses, possibly due to the delayed recovery of invertebrate food organisms after dredging in 1978. The result is probably an underestimate however, because of the difficulties of adequate sampling of such open waters by electric fishing and seine netting. Twelve species of fish were found and (discounting sticklebacks) roach, tench, bream and pike accounted for 81.4 per cent of the biomass and 80.9 per cent of the total numbers. At the time of writing, plans were being made to restock the Lake with a further 40 – 50kg of mixed carp to bring the minimum biomass up to 20g m^{-2}. Recovery of invertebrate food sources should certainly now be adequate.

The TWA survey also showed that the Foots Cray part of the river is supporting a good fish stock. Upstream of the study area, 35.55g m^{-2} of fish were caught, though this high figure probably represents a more exhaustive and efficient fishing effort and catch than was possible at Five Arches. Minnows, gudgeon, roach and eels were most plentiful but the introduced brown trout were also doing well and breeding. A healthy salmon parr, the only one caught in the whole survey, was found in this area, suggesting water quality must be quite good and food supply adequate.

Conclusions

In terms of general ecology and biology, one of the most striking features of the study area is the gradation of current speed and substrata which produce a range of conditions from purely riverine to virtually lacustrine. This is matched by the distribution and relative densities of the invertebrate species found. This further relates to the effects of the pollution spill and dredging; all riverine species showed relatively low densities at the beginning of the study and the scarcity of *Hydropsyche, Baetis* and juvenile *Gammarus* suggests that the caustic soda spill had very severe effects in the river. Species diversity was not abnormally low at the beginning of the study because of recolonization from stretches upstream of the point of pollutant entry. Recovery of numbers, however, was delayed until after late spring and, especially, late summer breeding periods in 1979.

Whether the caustic soda had such drastic effects on invertebrates in Five Arches Lake is difficult to say. As discussed earlier, retention time is relatively short and most of the flow is restricted to one side and thus the caustic soda would perhaps have had less effect at the more isolated and lacustrine Station 6 and nearby areas, especially on resistant forms (e.g. leech egg capsules). In this case, it is probable that dredging had the more severe effects by both removing organisms and the sediments and detritus to which they are adapted. The more mobile individuals that avoided the dredge and those on the island fringes would have provided recolonizers to give the fairly high diversities at the beginning of the study. Full recovery of numbers, however, was apparently delayed until sufficient sediments and organic debris (especially from leaf-fall) built up later in 1979. The fish survey data support the view that recovery in 1978 – 9 was sufficient to encourage redevelopment of the lake as a coarse fishery.

The timing of the pollution and dredging were unfortunate in that the former (in April 1978) would have affected summer breeding in Five Arches Lake. Only the timing and extent of the dredging could have been controlled but since loss of sediments and organic material had more lasting effects, the timing was relatively

unimportant. Because of the problems inherent in excessive sedimentation, enrichment and decreasing water depth, the long term effects of dredging can only be beneficial. This also applies to the introduced fish and the value of the Lake as a leisure fishery, let alone its value as a canoe pool.

The types of species and diversity and the physicochemical data all indicate that the study area suffers little from pollution, bar organic enrichment (probably largely of natural origins) and accidental spillages. A useful comparative index of the River's quality is that used by the National Water Council, as discussed in Aston *et al.* 1979. There are six classes in this scheme (based on physicochemical and biological criteria), ranging from 1A (high quality waters) to 4 (grossly polluted) and finally, x (insignificant streams). The riverine section in this study would be classified as Class 2B on the criteria that BOD was sometimes more than 3ppm and that it was known to have received toxic discharges which had been removed by natural processes. In addition, it was occasionally fairly turbid though this had little deleterious biological effect. The River met the criteria for biotic classification B in that Plecoptera were absent and Ephemeroptera populations were fairly restricted, but that *Gammarus* and Trichoptera were present in reasonable numbers and the invertebrate community as a whole was quite varied. Such rivers form good mixed coarse fisheries, as is the case at Five Arches. The Lake itself is almost in Class 2 but it could not be expected to meet all the criteria to be called Class 2B, as the scheme is designed only to compare riverine communities.

The classification of 2B compares with that of 1B given by TWA for the Cray just upstream of the tideway (Aston *et al.* 1979). This conflict is explained by the more eutrophic nature of the River at Foots Cray. Sediments settle out in Five Arches Lake and biological purification occurs, resulting in a better downriver quality. This process also occurs as the River passes throuh Ruxley Lakes (Heal & Bailey 1974) and others further downstream. It is interesting to speculate on what the quality of the Cray would be like if it were not for these 'sediment traps'. Because its gradient is not very steep and its catchment area not very large, flow rates and flushing are not very fast, except in winter spate. Thus urban and industrial pollution from the upper reaches and natural eutrophication would probably have much more widespread and deleterious effects.

The River at Foots Cray is vulnerable to pollution accidents but it seems that recolonization can easily occur, though full recovery may be delayed until a full year's breeding is possible. Ruxley Lakes are of relatively minor importance as a source of recolonizers in comparison with the upper river stretches (except for lacustrine species with flying adult stages). It follows that a pollution accident occurring at or near Station UR (e.g. from nearby industrial premises or due to an accident on the present or projected A20 trunk road) is a great potential threat. This could lead to devastation of the whole river stretch, recolonization would be much delayed and the fishery would be badly affected.

Although this study was carried out over 17 months, some points remain to be clarified. It would be of interest to continue detailed surveys to see whether the recovery really is complete and whether any future changes in diversity and community structure occur. Studies of relationships between the invertebrate fauna and the fish would also be useful, as would studies of the flora. The data and discussion presented should, however, provide a good basis for comparison if the study area should change in any way, or be affected by any further pollution accidents. They certainly show that the River, despite the unsightly urban and industrial debris usually present, is of generally good quality as a metropolitan water course and quite capable of supporting a good coarse fishery.

Acknowledgments

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The Weybridge Salmon

by Alwyne Wheeler*

The return of fishes to the tidal parts of the River Thames has vividly demonstrated its improved condition after many years of pollution. The most significant species in this respect are those migratory fish such as salmon *Salmo salar* (L.), smelt *Osmerus eperlanus* (L.), flounder *Platichthys flesus* (L.), and eel *Anguilla anguilla* (L.), which in the course of their lives migrate from the sea into fresh water and then return to the sea, thus passing through the metropolitan reaches of the river which were most severely affected by pollution in the nineteenth and twentieth centuries. The details of past and present abundance of these fishes and the history of the pollution of the river and its restoration can be found in my book *The Tidal Thames. The History of a River and its Fishes* (Wheeler 1979), but the purpose of this note is to draw attention to a fish which was at one time well-known, if not controversial, and which has been latterly overlooked even though its stuffed body is still available for examination. This is the salmon found by Mr George Keene in 1861 in the River Thames at Weybridge and now preserved in the Weybridge Museum. Recent examination has proved that it was a salmon. Because it was found at a time when the Thames was thought to be too severely polluted to permit the passage of migratory fishes, and because recent authors writing on migratory fish in the Thames (e.g. Solomon 1976) have not commented on this specimen, its history is worth recounting.

The fish, according to the label on its case was 'Taken in the Thames, at Weybridge Surrey, 9th March 1861 weight 23½ lbs; length 40 inches; girth 22 inches'. These details were virtually as given by J. E. Harting (1911), and earlier by Bainbridge (1889). The pseudonymous Red Quill (1902) was a witness to the 'capture' of this fish, and wrote, "he [Mr George Keene] found a large dead trout floating in the river, much larger than any live specimens of *Salmo fario* which the Thames has yielded to rod or net in recent times. It weighed about either 22 lb or 27 lb. I saw and handled it myself. It was a long lean fish, very much out of condition, only faintly spotted, and both upper and lower jaws beaked, indicating old age. Somehow it looked different to a Thames trout, and led to the suggestion and surmise that it had been derived from some other source, and placed after death in the river. There was a mystery about it, never cleared up, and few anglers believed — George Keene did not — that it had been a native of our noble river." According to Harting (1911) there had also been reports that the fish was found in a dying condition but not dead (these may have originated in correspondence in the *Fishing Gazette* of 21 June and 12 July 1890 which referred to the fish as 'dying' and in a 'moribund state'). That the fish was picked up dead seems more probable in view of Red Quill's eye-witness account even though it was written forty years after the event, and it receives support from the label on the case which reads 'Taken in the Thames', whereas two large Thames trout caught by Keene which were also stuffed and mounted by the same taxidermist were labelled 'Killed at Weybridge, April 3, 1858'.

The identification of the fish caused problems from the first, as was suggested by Red Quill's reservations (quoted above). He, and presumably Keene, regarded it as a trout, *Salmo trutta (S. fario* is a synonym). According to Harting (1911) while it was with the taxidermist John Cooper (of 28 Radnor Street, St Luke's, London) it was seen by Frank Buckland who expressed doubt as to its being a Thames trout but 'hesitated to pronounce it a salmon, apparently on account of its origin'. It was also seen at that time by Sir William Jardine who declared that

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the fish was a salmon. Now both Buckland and Jardine were authorities on salmonid fishes, Jardine being a Commissioner for the Salmon Fisheries of England and Wales from the foundation of the Commission in 1860, and Buckland becoming Inspector of Salmon Fisheries in 1867, and Buckland's doubt that it was a trout and Jardine's positive assertion that it was a salmon are interesting. The problem was that by 1861 the tidal Thames was so polluted and the lower weirs were so high, that no one could admit that a salmon could have migrated up river as far as Weybridge. Presumably because of the 'impossibility' of its being a salmon in the Thames at this place the fish was usually referred to as a trout.

The stuffed fish remained with Keene's widow for a while after his death, but in 1889 it was sold and eventually presented to the Weybridge Museum in 1911. J. E. Harting, who was closely involved with the foundation of this Museum, had the specimen examined by G. A. Boulenger of the British Museum (Natural History) who confirmed that it was a salmon (Harting, 1911). This confirmed the opinion of the Museum's committee.

Through the courtesy of Mrs Avril Lansdell, Curator of the Weybridge Museum, I have examined the fish, which has now been removed from its original bow-fronted case and placed in a case from which the front can be removed. The fish now measures 980mm (38.6in) total length. Judging from the length of the premaxilla (which reaches only as far back as the rear edge of the glass eye), the narrow caudal peduncle, and the ten scales between the lateral line and the adipose fin base, there is no doubt that this fish is a salmon. The strongly hooked jaws form the kype typical of both salmon and large trout in spawning condition.

The identification of this fish as a salmon raises the interesting point as to whether this salmon swum up the Thames from the sea or was it disposed of into the river by a local tradesman, as suggested by Harting (1911) — it being an offence to be in possession of a breeding salmon. Harting reported that the Museum's committee and Boulenger felt the latter explanation was most probable, and indeed it cannot be ruled out. However, there is an inherent improbability that a 'tradesman' (presumably a fishmonger was intended) would embarrass himself with an unsaleable and illegal fish which eventually had to be thrown in the river to dispose of it. But, it has to be admitted as a possibility.

On the other hand there are pointers which suggest that the fish could have swum up the Thames. The period 1859 to 1862 saw a number of salmon captured in the lower reaches of the tidal Thames (Day 1887, Wheeler 1979). Most of them were caught in the vicinity of Erith and Dartford in the autumn months, which is the period salmon had formerly run up the Thames before the native stock was extinguished. This becomes significant in the context that the fourth quarter of the year is distinguished by heavy rainfall and with high upland flows the polluted water of the estuary becomes diluted. It is thus possible for a migrating salmon to pass through apparently impassably polluted river reaches during the short period when upland flow is high. High flows of upland water also make migration over weirs easier for active swimmers like salmon.

To summarize these points, the Weybridge salmon was taken during a period when there were a number of adult salmon in the mouth of the river. It was a fish in spawning condition, found in March (when it should already have spawned) and this is when an unspawned single fish might well have been found following migration up-river in October – November of the year before.

In the period since pollution has declined in the tideway several adult salmon have been found in the Thames, two of them in the non-tidal river. Details of

both have been given by Wheeler (1979) and one of them almost exactly matches the Weybridge fish in circumstances. On 30 December 1976 a fresh, but somewhat damaged, salmon was found stranded at the mouth of the River Ember, close to the confluence of the River Mole and the Thames near Hampton Court. This fish was in poor condition and was an unspawned male. The second salmon was found decomposing in the weir-pool at Shepperton in September 1978, and was possibly the fish seen leaping below the weir earlier in the summer.

Although neither fish was captured alive in the river there is no reason to suppose that they did not swim up the river. The only major difference between the River Ember fish and the Weybridge salmon is that the former is presumed to have migrated through a cleaner tideway than the latter. Clearly, in conditions of high river flow the lowest weirs in the non-tidal river are not insurmountable by mature salmon and would have posed no greater barrier to the Weybridge salmon.

It therefore seems probable that Mr George Keene's Weybridge salmon was present in the river as a result of migration, and not as a result of being discarded by an unscrupulous fishmonger or angler. If this is so then it reduces the period in which salmon were absent from the river by about twenty-eight years, for the last salmon has hitherto been said to have been caught in June 1833. However, it is unlikely that the Weybridge salmon was a true Thames fish, bred in the river, but was one of the stock of salmon that migrate in the North Sea and occasionally enter rivers like the Thames as did the four large fish which were caught or found in the river in the 1970s.

Acknowledgement

I would like to thank Mrs Avril Lansdell, Curator of the Weybridge Museum, for drawing my attention to the existence of Mr Keene's salmon and for making arrangements for me to examine it.

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Populations of Blue and Great Tits at Perivale Wood

by P. J. BELMAN*

Summary

A nine-year study of a nestbox population of blue and great tits at Perivale Wood, west London, is described. The number of nestboxes was changed each year and while blue tit breeding density increased as more boxes were provided, great tit density remained constant.

Blue tits move locally up to 3km and nestlings show more site fidelity than great tits. The female breeding population contained 33% first-year birds of which up to 62% were immigrants. Only one-quarter of the females are thought to have bred in their first year. Breeding densities ranged from 1.9 to 5.9 pairs per hectare and are limited by the availability of nestboxes.

Great tits move locally up to 5km and nestlings show less site fidelity than blue tits. The female breeding population contained 38% first-year birds of which up to 82% were immigrants. Only two-thirds of the females are thought to have bred in their first year. Breeding densities ranged from 1.1 to 1.6 pairs per hectare and are limited by the number of territories the wood can carry, a limit that was reached in most years.

Introduction

Populations of blue tits *Parus caeruleus* and great tits *Parus major* are particularly suitable for nestbox studies since almost all great tits and most blue tits use boxes rather than natural sites when boxes are provided to excess. This paper describes a nine-year study at Perivale Wood in which the number of nestboxes was changed each year, and contrasts the tit populations of a suburban woodland with those from other areas.

Habitat

Perivale Wood Local Nature Reserve is an ancient pedunculate oak *Quercus robur* woodland situated in the Brent Valley in suburban west London. The reserve consists of 6.9 hectares of mature closed-canopy oak wood with several clearings, a shrub layer of hazel *Corylus avellana* and hawthorn *Crataegus monogyna* and a field layer of bluebell *Endymion non-scriptus* and bramble *Rubus fruticosus* agg. The western edges were dominated by mature elms *Ulmus procera* but these have been reduced to suckers following Dutch elm disease. There is a raised area of 0.8 hectares along the northern edge dominated by a mature elder *Sambucus nigra* thicket and a marshy area of 0.6 hectares in the south-west corner. To the south and east of the wood are 2.2 hectares of old pasture.

The reserve is surrounded by houses, warehouses and a railway embankment, with the Grand Union Canal and an extensive open area to the north around Horsenden Hill where there is a small oak and hornbeam *Carpinus betulus* wood. The wildlife of the reserve and the surrounding area has been summarized by Roberts and Edwards (1973). The flora has been described in detail by Roberts and Edwards (1974a) and the birds by Webb (1911), Bartlett (1962) and Roberts and Edwards (1974b).

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The nestbox study

Nestboxes have been used to increase the numbers of breeding birds at Perivale Wood since 1908 (Webb 1911). Several types of boxes have been used for tits, but the majority of those used in recent years have been built broadly on the pattern for small hole-nesting species of Flegg and Glue (1971), with protective metal plates to prevent hole enlargement by great spotted woodpeckers *Dendrocopos major* and grey squirrels *Sciurus carolinensis*, and placed on tree-trunks at a height of about 3m. Lower boxes have been used but these are notably less successful and are being phased out. While well-meaning human disturbance is the cause of losses from these accessible nestboxes, deliberate vandalism is fortunately surprisingly infrequent for a suburban reserve. Predation by weasels *Mustela nivalis*, which are hardly ever recorded at Perivale Wood, is unknown.

Blue and great tits are the only species to use the nestboxes in numbers and indeed few pairs now seem to nest in natural sites. Tree sparrows *Passer montanus* occasionally nest in the reserve, but for some reason have not colonized the nestboxes. A single brood of nuthatches *Sitta europaea* was reared in 1978, but no other species has nested in the tit boxes, at least recently. The only analysis of blue and great tit breeding data is that of Dodd (1971) for the years 1968 – 69, who also ringed many of the young in those years.

A detailed ringing study has been run from 1971 – 79 (Belman 1972, 1973) and all nestbox broods have been ringed each year except 1974, when a few were missed. The number of nestboxes has been varied between 24 and 80, placed fairly evenly throughout the wood and the marshy south-west corner, an area of about 7.5 hectares. The majority of breeding females were caught on their nests in five of the nine years, but the capture of great tits on eggs, or small young, was avoided because of the risk of desertion. Mist-netting was carried out extensively from 1971 – 73, and irregularly since, to follow bird populations through the year and assemble individual life-histories.

Results

Breeding success

The annual total of nest boxes, the numbers of nestlings and broods ringed and the mean brood-sizes are presented in Tables 1 – 4. No second broods were recorded, although a great tit unsuccessfully attempted a repeat clutch in 1973 after an early desertion. Blue tit brood-sizes have shown quite small annual fluctuations, while the number of broods and hence young reared varied considerably. Great tit brood-sizes have shown much larger fluctuations, but the number of broods, and especially nests, remained remarkably constant in all years. Brood-sizes for the two species moved in parallel in only five of the eight intervals between years, with both at a high level in 1973 and lowest in 1977, the year following the 1976 drought.

TABLE 1. *Number of nestboxes.*

1971	1972	1973	1974	1975	1976	1977	1978	1979
41	80	72	62	40	44	33	24	32

TABLE 2. *Number of nestlings ringed.*

	1971	1972	1973	1974*	1975	1976	1977	1978	1979
Blue tit	204	302	356	301	183	212	107	100	115
Great tit	40	58	50	39	49	33	23	43	69

TABLE 3. *Number of broods ringed (failed nests in brackets).*

	1971	1972	1973	1974*	1975	1976	1977	1978	1979
Blue tit	24(6)	39(4)	42(3)	40(1)	25(3)	27(1)	15(6)	13(1)	14(4)
Great tit	7(2)	9(2)	7(3)	7(2)	8(3)	6(2)	6(2)	8(0)	12(0)

TABLE 4. *Brood-size at ringing.*

	1971	1972	1973	1974*	1975	1976	1977	1978	1979	Mean	S.D.
Blue tit	8.5	7.7	8.5	7.7	7.3	7.9	7.1	7.7	8.2	7.84	0.49
Great tit	5.7	6.4	7.1	5.6	6.1	5.5	3.8	5.4	5.7	5.70	0.89

*The 1974 data are incomplete. Included above are single broods of blue tits outside the LNR boundaries in 1971 (8), 1973 (7) and 1975 (7) and a single brood of great tits within the LNR in a natural site in 1971 (8) and 1972 (4).

Nestboxes were stocked at between 3.2 and 10.6 per hectare in different years, resulting in breeding densities of blue tits of 1.9 – 5.9 pairs per hectare and great tits 1.1 – 1.6 pairs per hectare. That the large variation in the number of blue tit broods reared was due to changes in the number of nestboxes available is shown clearly in Fig. 1. Blue tits usually lose in contests with great tits for nestboxes, but as the highly territorial great tits require only a limited number of boxes the remainder are available for blue tits. Thus if the number of nestboxes is increased the breeding population of blue tits also increases (Perrins 1979).

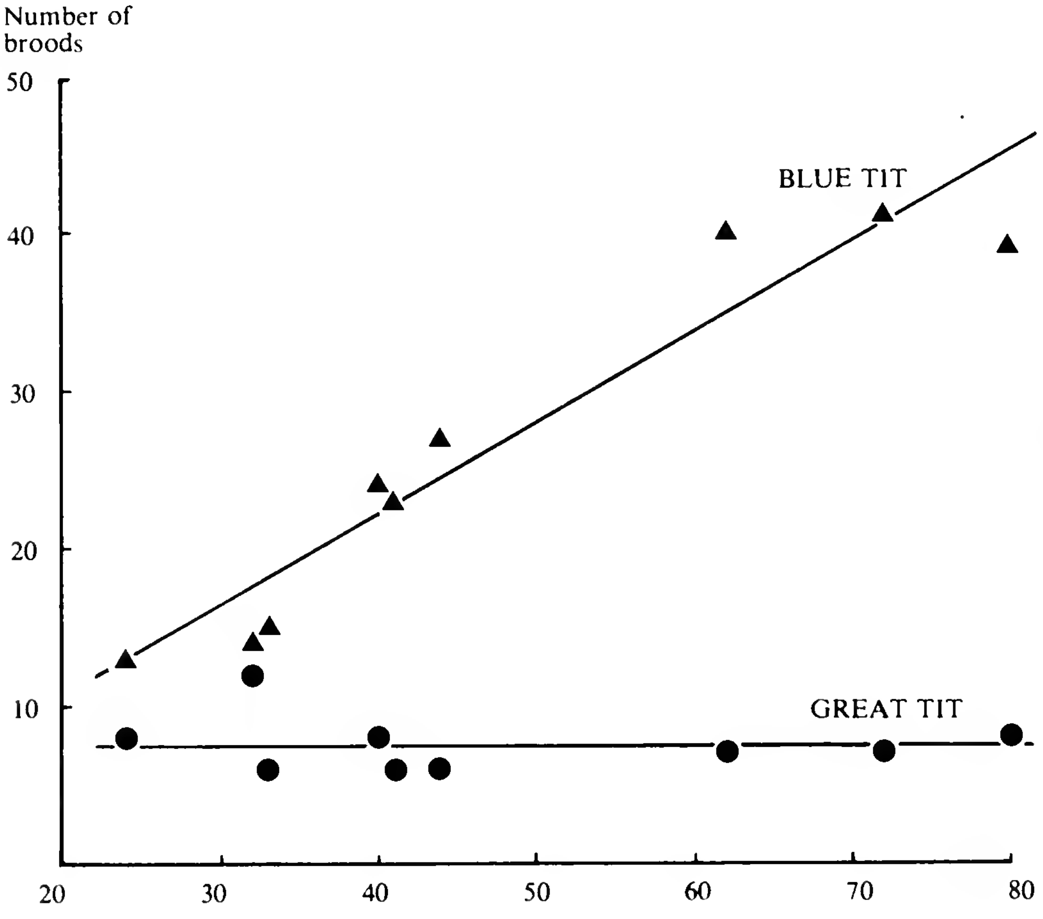

FIG. 1. Effect of varying the number of nestboxes.

Nestling survival, dispersal and mortality

All recaptures or recoveries of each year's cohort of nestlings in later years are listed in Tables 5–6. The figures are not comparable from year to year since trapping effort was not constant. Nevertheless the blue tit data show that each year's nestlings contributed to the breeding population in later years, with the oldest surviving to six years of age. Twenty-three female blue tits ringed as nestlings were subsequently recaptured when breeding, and the distances moved from the birthplace are given in Table 8. Two bred in the same box in which they were born but the median dispersal was 170m. Only dispersal within the reserve can be recorded by this method, up to 400m between the most widely separated boxes, and it must be assumed that many blue tits moved outside the reserve to nest. Ringing recoveries of nestling blue tits were usually not more than two, or rarely 3km from Perivale Wood, although one was killed 7km north-east the following May and another was caught 35km north-west at Tring the following February.

TABLE 5. *Survival of blue tit nestlings.*

Year of hatching	*Calendar year of recapture or recovery* 0	+1	+2	+3	+4	+5	+6	+7	+8
1971	7	4	5	—	—	—	—	—	—
1972	30	22	4	1	3	—	—	—	
1973	3	6	3	1	1	—	2		
1974	2	3	8	3	—	—			
1975	1	3	1	—	1				
1976	5	—	—	4					
1977	—	2	4						
1978	3	10							
1979	1								

TABLE 6. *Survival of great tit nestlings.*

Year of hatching	*Calendar year of recapture or recovery* 0	+1	+2	+3	+4	+5	+6	+7	+8
1971	3	1	1	—	—	—	—	—	—
1972	2	1	1	—	—	—	—	—	
1973	—	—	—	—	—	—	—		
1974	1	—	—	—	—	—			
1975	—	—	—	—	—				
1976	3	—	—	—					
1977	—	—	—						
1978	1	2							
1979	2								

Fewer great tit nestlings than might be expected were found in the reserve in later years and only two females have subsequently been discovered breeding, having moved a median distance of 135m from their birthplace. This suggests that the majority of great tits born in Perivale Wood disperse elsewhere to nest. Bulmer (1973) found that female great tits at Wytham Wood, near Oxford, moved 775m to breed and males 475m, although only dispersal within the wood could be recorded. Ringing recoveries show slightly more local movement than blue tits, up to 5km away from Perivale Wood.

TABLE 7. *Post-fledging mortality of nestlings.*

		Month of recovery J	F	M	A	M	J	J	A	S	O	N	D
Blue tit	*Same year*						4	1	—	—	—	1	—
	Later years	1	—	—	1	7	1	—	—	—	1	—	1
Great tit	*Same year*						1	—	—	—	—	—	—
	Later years	—	—	1	1	—	—	—	—	—	—	—	—

TABLE 8. *Dispersal of breeding females from birthplace (within Perivale Wood).*

	Movement (in metres) 0	20	50	80	110	140	170	200	230	260	290	320	Median
Blue tit	2	—	2	2	1	1	6	2	3	2	1	1	170
Great tit	—	—	—	—	—	2	—	—	—	—	—	—	135

The first young tits are recovered away from the reserve in June. Goodbody (1952) and Gibb (1954) demonstrated an explosive dispersal of juveniles of both species within a month of fledging, which had the effect of rapidly diluting the populations with emigrants being replaced by immigrants, but after the beginning of July little further dilution occurred. This was observed at Perivale when blue tits were mist-netted in all months except two from June 1972 to April 1973. Over 80% of juveniles caught in June had been ringed in the nestboxes but this figure dropped to 40% in July and remained steady until the spring.

Table 7 shows the month of recovery of nestlings found dead after fledging in the same year and in later years of life. Blue tit mortality is greatest immediately after fledging and during the latter part of the nesting season in later years. The great tit data are inadequate but hint that mortality may occur in the early part of the breeding season, perhaps because of the more vigorous territorial behaviour of this species.

The breeding population

The age structure of the female breeding population is outlined in Tables 9 – 10. All blue and great tits breeding when one year old can be distinguished on plumage characteristics, so the proportion of young birds in the breeding population is known each year that a reasonable sample was caught. The proportion of one-year-old great tits was 38%, rather higher than that of blue tits, 33%. Only birds that had previously been ringed in their first year of life could be placed in older age categories, but two six-year-old blue tits and one seven-year-old great tit were found.

TABLE 9. *Age of breeding female blue tits.*

	Number caught	Known age *1*	*2*	*3*	*4*	*5*	*6*	*% 1-year*
1971	26	10	1	—	—	—	—	38
1972	22	9	4	1	—	—	—	41
1973	32	13	4	4	—	—	—	41
1974	4	4	—	—	—	—	—	100
1975	11	3	—	1	2	1	—	27
1976	8	1	—	—	—	2	—	12
1977	15	2	1	4	1	—	1	13
1978	6	2	1	1	—	—	—	33
1979	17	2	2	3	—	—	1	12
Total	141	46	13	14	3	3	2	33

TABLE 10. *Age of breeding female great tits.*

	Number caught	*Known age* 1	2	3	4	5	6	7	% *1-year*
1971	8	4	—	—	—	—	—	—	50
1972	5	2	1	—	—	—	—	—	40
1973	9	3	1	2	—	—	—	—	33
1974	4	1	1	1	—	—	—	—	25
1975	3	1	—	1	—	1	—	—	33
1976	1	—	—	—	—	—	—	—	0
1977	3	1	—	1	—	—	—	1	33
1978	1	—	—	—	—	—	—	—	0
1979	5	3	—	—	—	—	—	—	60
Total	39	15	3	5	0	1	0	1	38

Snow (1956) found that the proportion of young blue tits in the spring population was 70%, so only about one-quarter of the females nest in their first year at Perivale Wood. The proportion breeding was correlated ($P < 0.05$) with the number of nestboxes available, implying that the young are at a disadvantage in competing for nest sites. Bulmer and Perrins (1973) thought that all female great tits bred in their first year at Wytham, although only 66% of males did, and the proportion of young females in the breeding population was 53% (*op. cit.* Table 1). Krebs (1971) demonstrated a small increase in the proportion of first year males in sub-optimal habitat (hedgerows), so it is interesting that about one-third fewer female great tits nest in their first year in pure oak at Perivale Wood than in mixed woodland at Wytham.

The rate of immigration into the breeding population is indicated by the proportion of young caught on their nests not ringed as nestlings the previous year. More immigrant female great tits, 82%, than blue tits, 62%, were found, although these figures are overestimates since they contain a small number of birds fledged from natural sites in the wood and not detected. There is no reason to think these immigrants were not mainly drawn from the surrounding area, but one great tit nestling ringed near Enfield was caught 20km south-west in Ealing the same winter, and one blue tit nestling from Gerrards Cross was caught 20km east-south-east in Ealing the same autumn. In addition a young blue tit ringed in November at Perivale was caught 48km east-north-east at Blackmore, Essex the following March and a one-year-old female blue tit ringed on its nest at Perivale was found in February five years later 31km north-north-east in Welwyn Garden City.

Discussion

Breeding densities of both blue and great tits are highest in pure oak woodland, although great tits depend less on the presence of oak in broad-leaved woods. Previous studies summarized by Lack (1966) have shown densities as high as, and higher than, those in Perivale Wood for the great tit, but the breeding densities of blue tits in those years when most nestboxes were provided were much higher than have been reported elsewhere (Lack 1964). The remarkably constant number of great tit nests is unexpected, as other studies have shown that simultaneously over a large area of western Europe the number of breeding great tits tends to see-saw from year to year with the size of the previous year's beech *Fagus sylvatica* crop, in turn an indicator of the crop of other tree species including oak, although the reasons for this are not understood (Perrins 1965, 1979; Lack 1966). Why Perivale great tits should be the exception is not clear. Perivale Wood differs most obviously from other study sites in that the greater part of the surrounding area into which young great tits disperse contains suburban gardens which may provide an artificial food supply that is independent of tree crops or other related factors.

Only the most severe winters have been found to affect the number of great tits breeding the following year in Britain, and it is worth pointing out that after the hard winter of 1978 – 79 great tits bred in slightly larger numbers at Perivale Wood than in any other year. Breeding numbers are also largely independent of the number of young fledged the previous year (Lack 1964). Rather it is mortality in the first month after leaving the nest that determines the proportion of young in the winter population and the size of the breeding population (Gibb 1954, Perrins 1963, Lack 1966). Dispersal of the juveniles occurs during this critical period and if artificial food is in fact used at this time it should have a stabilizing effect on the number of young surviving to breed. Food provided from October to April at Wytham had no effect on the breeding density of great tits, but did increase the breeding density of blue tits (Krebs 1971).

At Perivale the great tit breeding population seems to be limited by the number of territories the wood can carry, a limit that is reached in most years, while in other areas studied this limit is only reached in some years. The range of breeding densities found at Perivale Wood, 1.1 – 1.6 pairs per hectare, is average when compared to densities in other broad-leaved woodlands where densities in peak years were in excess of three pairs per hectare (Lack 1966). Since one-third of the young female great tits do not appear to nest at Perivale there must be a reason that territory sizes are not reduced to accommodate the surplus as has been noted elsewhere in peak years. Krebs (1971) observed that great tits were able to maintain a larger territory at the edge of a wood since they were competing with fewer neighbours. The small size of Perivale Wood would exaggerate this edge effect and explain why territories are not further compressed. In contrast, the blue tit breeding population at Perivale is limited by the number of nestboxes and in spite of the high densities achieved the carrying capacity may not yet have been reached.

Great tit brood-sizes at Perivale are lower than in other broad-leaved woodlands studied (Lack 1955). In peak years elsewhere breeding success was reduced as density increased (Lack 1966). Thus low brood-sizes could be taken as confirmation that the Perivale Wood population is at maximum density in most years. However territory sizes at Perivale are as large every year as in years of only average density at other sites, which would imply that breeding success was in some way affected by competition for the territory rather than by its size. There is a single case of low breeding success in oak woodland elsewhere. Lack (1955) reported low clutch-sizes and low breeding densities in an urban oak-wood at Coventry studied from 1951 – 53, which were attributed to smoke pollution.

Information on the pattern of local movements is particularly easily obtained since Perivale Wood is surrounded by populated areas giving an improved chance of dead ringed birds being found, and finding localities are usually accurately reported as place names change over quite short distances. Blue tits appear to move within a narrower area than great tits, up to 3km rather than up to 5km, and this is confirmed by the lower rate of immigration of blue tits. Only a small proportion, about 8%, of both species moved more than 10km. Perrins (1979) found that local movements of blue tits were the more extensive at Wytham, a difference that can perhaps be explained by the greater distances these birds were travelling in a rural area to feed in gardens.

What is the optimum density of nestboxes for Perivale Wood? Gibb (1954) suggested that the provision of nestboxes for great and blue tits freed natural sites for other species and both marsh tits *Parus palustris* and willow tits *Parus montanus* might benefit indirectly in this way from high nestbox densities at Perivale. There is evidence of competition for boxes between adult and young blue tits in years when few were provided, and the number of blue tits nesting is

clearly limited by the number of nestboxes. It is therefore important that the number of boxes should be maintained in future years at, or even above, the highest levels used during this study.

Acknowledgments

I would like to thank the many people who helped with this study over the years, and particularly David Frusher for organizing nestbox maintenance and R. A. Austin for ringing the nestlings in 1974. Dr R. J. O'Connor, Dr C. M. Perrins and Dr K. A. Roberts kindly read an earlier draft.

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Survey of Bookham Common:

THIRTY-EIGHTH YEAR

Progress Report for 1979

General (G. Beven*)

It is sad to report the death in April 1978 of S. H. Chalke. During the early years of the bird census of Eastern Wood he was an enthusiastic member of the team which worked out the details of the census technique.

In September 1979 a start was made on the laying of a main sewer across Bookham Common from the sewage works at Bookham to the main works at Leatherhead. The route of the pipeline crosses Bayfield and Isle of Wight Plains to skirt the north-west boundary of the Isle of Wight enclosure, along Glade Path and Stents Path, through 'The Birches' to leave the Common at ref. 264. A track has been cleared ten metres wide and a trench dug two metres wide for the sewage pipe which is laid in gravel. The natural vegetation is to be allowed to regenerate along the bare track and it will be interesting to observe the progress of recolonization.

Vegetation (Bryan R. Radcliffe†)

When it became known that excavation work for a sewage pipeline was imminent and that the route was in the vicinity of 'The Birches' a clear threat existed to our colony of the thin-spiked wood sedge *Carex strigosa.* This species is scarce in Surrey. The Bookham population, some fifty plants confined to an area of about seventy five square metres, is the only one known on London Clay in the Surrey portion of the LNHS area.

In the absence of precise knowledge of the pipeline route it was considered prudent to remove some of the plants to places of safety elsewhere on the Common. Five sites were selected, at 256, 264, 283, 516 and 674. Two individuals were planted at each in September 1979. All were still present and alive in November of the same year.

When excavation commenced an area denuded of all vegetation extended at least 5 metres each side of the pipe trench, and marginal mounds of topsoil and clay were deposited. Pipelaying was completed before the end of the year.

The disturbance, which might have obliterated the entire colony of the sedge, fortunately missed its centre. It is thought that a few plants may be buried under a marginal dump and these could be lost when the area is re-levelled, but the bulk of the colony is intact. Assuming that local drainage characteristics of the soil are not substantially altered by the gravel-encased pipeline we can be optimistic about the future of the colony.

Field work on the re-survey of the vascular plants terminated at the end of 1979. Work is now in hand to collate the data for a detailed comparison with the 1954 flora.

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It has been a good year for ferns. *Dryopteris filix-mas* and *D. austriaca* are now recorded from all twenty arbitrary divisions of the Common. Many new sites have been found for *D. carthusiana* and *Athyrium filix-femina,* while two additional clumps of *Polystichum setiferum* have been located. One crown of *Dryopteris pseudomas,* previously unknown here, is now on record.

Other noteworthy finds for the season include *Potamogeton pusillus,* not known before but present in enormous quantity in the recently re-created Upper Hollow Pond, *P. obtusifolius* sparingly in the same, *Isolepis setacea* on the margin of Isle of Wight Pond, *Alopecurus aequalis,* noted some years ago by Mrs J. E. Smith by Lower Eastern Pond but disbelieved by some, now re-found and given unimpeachable confirmation, and two plants on Central Plain believed to be the hybrid *Dactylorhiza praetermissa x fuchsii:* both putative parents are known in the vicinity.

The opportunity is taken to put on record the introduction of one young sapling of *Sorbus torminalis* in 1977. Nigel Davis, who was Keeper at the time, obtained the tree from nearby Banks' Common and planted it at ref. 554 in an area of regenerating woodland. It is currently (Jan. 1980) approximately 2.5m high, having a stem diameter of 1.5cm at a height of 1m and appears to be thriving.

Bryophytes (R. C. Stern*)

Mr O. B. J. French has continued to make intensive investigations on the Common and has added many new locality records. Miss E. M. Hillman has also contributed some new records and Mr R. C. Stern has assisted with identifications and has visited on a few occasions. Work is under way on the preparation of a bryophyte flora of the Common.

The following have been found new to the Common or have been rediscovered for the first time since before 1967. The habitats are as given in Miss Hillman's paper in *Lond. Nat.* **54** : 49 – 58 (1975) and nomenclature follows the 1963 *Census Catalogue of British Mosses* by E. F. Warburg.

	Area	Habitat	Remarks
Campylopus flexuosus (Hedw.) Brid.	T	S	
Tortula laevipila (Brid.) Schwaegr.	S	7a	On *Salix fragilis*
Tortula latifolia Hartm.	D	7b	Found in 1975 by Mr J. C. Gardiner; new record.
Ephemerum serratum (Hedw.) Hampe var. *minutissimum* (Lindb.) Grout.	F & J	6b	
Zygodon conoideus (Dicks) Hook. & Tayl.	C	7a	New record and new to Surrey.
Ulota crispa (Hedw.) Brid.	A & E	7a	
Drepanocladus aduncus (Hedw.) Warnst.	D	1b	
Brachythecium albicans (Hedw.) B.S. & G.	D	2a	
Rhynchostegiella pumila (Wils.) E.F.Warb.	D	6b	
Hypnum cupressiforme Hedw. var. *filiforme* Brid.	I	7a	New record.

Mr O. French found the relatively rare moss *Physcomitrella patens* (Hedw.) B.S. & G. in considerable abundance on dried mud in Upper Hollow Pond.

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Beetles Associated with Elm Trees (Richard A Jones*)

Future students of ecology will look back on the mid nineteen seventies as the years of Dutch elm disease. Thousands of huge and ancient trees have disappeared within two or three years. This event has constituted the greatest upheavel in English ecology in this decade. The only area to evade the ravages of the disease is East Sussex, where there are probably more living mature elms than in the rest of the country. Bookham Common has lost all its elms, and I give here a brief account of one aspect of their ecology and the beetles found associated with the trees as they withered and died. This is probably a fairly accurate mirror of the nationwide state of the beetle ecology of elms.

The English elm *Ulmus procera* Salisb. was widespread over England and Wales, not reaching the Scottish border. It was mainly found in hedges and beside roads and was most often planted. The larger trees would be found along old boundaries and causeways. The Bookham elms were also in hedges and along the boundaries. They occurred along the edges of the Common from Lady Chewton's Wood (238) to Hundred Pound Bridge (188) and from Banks' Common (445) to Maddox Lane (768). Another old hedge was left unkempt and overgrown to become Station Copse (886), but unfortunately all the diseased trees in Station Copse had been felled and burned by 1976, before my first visit.

Dutch elm disease *Ceratostomella ulmi* Bismun is a fungus transmitted by bark beetles of the genus *Scolytus* Müller. The last bout of the disease to occur in Britain was during the nineteen thirties and forties, but the destruction was on a far less severe scale. It died out without much effect, after a period of minor infection. This was presumably because either there were fewer *Scolytus* at that time, or the conditions for the survival of the beetle were wrong. Thus the spread of infection was inhibited. This time however, the strain of fungus was more virulent, the beetle was plentiful, and conditions for its propagation perfect. The devastation is evident!

The destruction of most British elms has provided an abundant temporary habitat for any beetle living in dead wood. However, the investigation at Bookham revealed rather more inhabitants than might have been expected. These could be broadly classified as follows:-

1 beetles connected with Dutch elm disease.
2 other beetles normally found under bark and in wood.
3 beetles found sheltering under bark that are not normally associated with dead wood.
4 beetles feeding on the leaves of elm.

The beetles responsible for the spread of Dutch elm disease are *Scolytus scolytus* (Fabricius) and *S. multistriatus* (Marsham). They both emerge in April and I have only found them by sweeping and beating. The larvae were very common under any elm tree in 1977, but with the death of the trees are no longer to be found. The bark of the dead trees can be seen to be riddled throughout with the borings of these beetles.

Within the *Scolytus* burrows occurs *Corticeus bicolor* (Olivier). This beetle is predatory on the larvae of *Scolytus* and after being very scarce for a number of years has suddenly increased enormously in numbers. Easton (1948) records it from Kelsey's Pond (255), but I have found it commonly in Lady Chewton's Wood, and along the edges of Kelsey's Wood, Banks' Common and Bayfield Plain. Another beetle predatory on *Scolytus* is *Aulonium trisulcum* (Fourcroy).

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Unrecorded for many years, it is now occurring all over Britain and I found it at Bookham, one specimen only, near Kelsey's Pond in November 1978. The *Scolytus* have now disappeared and so have *Aulonium* and *Corticeus,* because there is no longer any living mature elm bark on the Common.

Most other beetles found under bark are not so specific to elm. *Dromius quadrinotatus* (Zenker), *D. quadrimaculatus* (L.) and *D. meridionalis* Dejean are common under elm bark. Easton (1952) however only records *D. meridionalis* beaten from elm and the other two species mainly from squirrel dreys. This suggests that the occurrence of the new habitat under bark has provided for these beetles a new niche to colonize. *Gabrius splendidulus* (Gravenhorst) and *Siagonium quadricorne* Kirby are bark-feeding staphylinids and both occurred under moist bark of fallen elms in 1977 in Lady Chewton's Wood. A third staphylinid associated with bark is *Phloeonomus punctipennis* Thomson which I have found only at the edge of Bayfield Plain (723).

Under a dried white fungus on a stump I took *Dacne bipustulata* (Thunberg), *Mycetophagus quadripustulatus* (L.) and *Litargus connexus* (Fourcroy). This was in 1978 on the Isle of Wight Plain. All are fairly common fungus-feeding beetles and I have taken them elsewhere on the Common, associated with other trees.

Lady Chewton's Wood had many very large elms, and in 1977 the felled trees yielded *Paromalus flavicornis* (Herbst), *Cerylon ferrugineum* Stevens and *Ischnomera caerulea* (L.). Easton (1948) recorded *Ischnomera* from hawthorn blossom, where it usually occurs, after its emergence in May.

Euophryum confine (Broun) was introduced into Britain during the nineteen forties and has since spread until it is now relatively common. I dug a single specimen out of the wood of an elm near Kelsey's Pond in 1977. Easton (1946) did not record this species from Bookham, but his list was published very soon after the beetle was first discovered.

The only bark beetle that I have never found under elm bark is *Magdalis armigera* (Fourcroy). It occurs in the small twigs and branches near the tops of the trees and consequently is taken by beating. Easton (1946) says of it 'Very common beating elms', but I have only taken it on one occasion, on Bayfield Plain in 1978. This may be due to the beetle's preference for living twigs, of which there are none any longer. On the other hand *Rhynchaenus alni* (L.) which lives in the leaves has not diminished in numbers. This is presumably because there are plenty of suckers and young shoots unaffected by the disease due to their small diameter which has prevented the *Scolytus* from attacking them.

In addition to the species which are normally found under bark, many others use loose bark as shelter. These include:-

Pterostichus madidus (Fabricius)	Banks' Common	(445)	1978
Staphylinus ater Gravenhorst	Bayfield Plain	(723)	1978
Tachinus sigmatus Gravenhorst	Kelsey's Pond	(255)	1977
Agonum assimile (Paykull)	Kelsey's Pond	(255)	1977
Quedius boops (Gravenhorst)	Kelsey's Pond	(255)	1977
Chrysolina menthastri (Suffrian)	Kelsey's Pond	(255)	1978

Of these *Agonum assimile* and *Chrysolina menthastri* are unrecorded by Easton.

With the failure of all the mature elms, the associated beetles will disappear, at least for a while. Although the trunks are dead, many surviving suckers, too small to be attacked by *Scolytus* and hence immune to the disease, will grow to a new

generation. It will be interesting to watch the beetles as elms begin once again to decorate the English countryside.

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Birds (G. Beven)

Population Studies in Oakwood

The breeding season census was repeated in the 16-hectare sample of dense pedunculate oakwood (Eastern Wood) in 1979. The most important change was a reduction in wrens, the number of territories during the years 1975, 1976, 1977, 1978 and 1979 respectively being 30, 22, 23, 33 and 18. The 1978 wren population was the highest since a census was begun in 1948. The 1978 – 9 winter was cold especially in January but in south-east England there were no periods of continuous frost lasting more than seven days. The other bird populations remained relatively stable.

Population Studies in Scrub and Grassland

The breeding season census was repeated in 39 hectares of scrub and grassland in 1979 (G. Beven and W. D. Melluish). The number of territories for 1975, 1976, 1977, 1978 and 1979 respectively were, for wrens 26, 23, 22, 26 and 18: and for robins 26, 32, 34, 30 and 40. Thus although wrens had decreased by 30%, robins had increased by 30%. A Cetti's warbler was present May – July.

Food of Long-eared Owls in Winter on Bookham Common

From about mid-January to mid-April 1979 a party of long-eared owls *Asio otus* roosted in thickets of blackthorn and hawthorn near Hundred Pound bridge (ref. 415 and 421). The birds were often difficult to find but there were at least six or seven in early February. The surrounding habitat was hawthorn and blackthorn scrub with rank herbage along Bookham Stream and nearby, bracken and oakwood. There was also a grass field adjacent to the roosting thickets. Pellets from two sites revealed the following prey, expressed as a percentage by weight (see H. N. Southern (1954) *Ibis* **96** : 384 – 410 and G. Beven (1965) *London Bird Report* **29** : 56 – 72):

	Total prey items	Total prey units	% prey units
Field vole *Microtus agrestis*	43	43	44
Wood mouse *Apodemus* sp.	23	23	24
Bank vole *Clethrionomys glareolus*	10	10	10
Common shrew *Sorex araneus*	2	1	1
Long-eared bat *Plecotus auritus*	1	0.3	0.3
Blackbird *Turdus merula*	1	4	4
Thrush *Turdus* sp.	1	4	4
Starling *Sturnus vulgaris*	2	8	8
Dunnock *Prunella modularis*	4	4	4.1
Wren *Troglodytes troglodytes*	1	0.5	0.5
	88	97.8	99.9

The figures from this small sample suggest that although the long-eared owls captured a great many small mammals (79%) they also caught many birds (21%). In contrast, previous winter feeding studies on Bookham Common of barn owl *Tyto alba* (*Lond. Nat.* 1961, **40** : 99) and tawny owl *Strix aluco* (*Lond. Bird Rep.* 1965, **29** : 56 – 72) suggested that the barn owl, hunting mainly in grassland and scrub, and the tawny owl hunting mainly in oakwood, both fed almost entirely on mammals, taking very few birds. The barn owls' 97% mammals included only voles, mice and shrews, but the tawny owls' 96% mammals included larger species (25%) such as moles, rabbits and rats.

Other Notes on the Birds

Little grebes hatched three young on Lower Eastern Pond. A quail *Coturnix coturnix* was heard calling on 3 June at 3.50am at ref. 413 by Leslie Baker and B. A. Richards. This appears to be the first record for the Common. Two immature moorhens were found dead at Isle of Wight Pond on 24 July. Both had swallowed fisherman's hook and line. There was one jack snipe on 14 January at ref. 884, one green sandpiper on Eastern Hollow Pond on 5 August and another on Bayfield Pond on 9 September. Up to 20 hawfinches were present in the western scrub area in February and March (B. A. Marsh and others).

Mammals (G. Beven)

The bones of a long-eared bat *Plecotus auritus* were found in a long-eared owl's pellet on 13 April at ref. 415 (identified by J. E. Hill, Brit. Mus. (Nat. Hist.)). This is apparently the first record for Bookham Common. The only other specific record of a bat from the Common seems to be that of a whiskered bat *Myotis mystacinus* from a tawny owl's pellet (*Lond. Nat.* 1955, **34** : 15). A rabbit *Oryctolagus cuniculus* was found dead of myxomatosis on 9 September at ref. 869 (Ian Swinney). A sett showing signs of occupation by badgers *Meles meles* was found by Ian Swinney in the north-eastern area of the oakwood on 11 November. Evidence of the presence of roe deer *Capreolus capreolus* was widespread during 1979.

Book Review

Form and Function in Animals. By J. L. Cloudsley-Thompson. (Patterns of Progress, Zoology Series, No. 10). 81 pp, 45 text figs. Meadowfield Press Ltd., Shildon, Co. Durham. 1978. £2.80.

The relationship between the structural adaptation of animals and their environment, so that they can exploit it beneficially, is a complex but interesting topic. Professor Cloudsley-Thompson refers to numerous selected examples of adaptation across a wide range of the animal kingdom. The subject is treated with enthusiasm, whilst assuming the reader has some experience of zoological terms. The locomotory adaptations of animals are treated extensively, with mention of feeding, respiration, excretion and evasion of enemies. The text is illustrated with many figures and plates, although the latter in the review copy are somewhat dark. Numerous references are given for those wishing to pursue the topic further.

BERNICE BREWSTER

A Survey of the Rabbit *Oryctolagus cuniculus* Warrens at Bookham Common after an Interval of Seven Years

by O. B. J. French*

Summary

The area known to carry rabbit burrows now appears to be considerably larger than it was during the period 1969 – 1970 but, while the number of animals has increased significantly, there seems to be no indication of an imminent population explosion. The distribution of rabbit communities has shifted to the northern woodlands, away from the southern and western plains. An attempt was made to consider the animals' food plants and to record some of the species apparently preferred by rabbits and those avoided by them.

Introduction

This study was conducted over the thirteen-month period from December 1976 to the end of 1977. During the seven years which have elapsed since the first survey was completed by M. Towns, while some of the original warrens have diminished in size or have become almost deserted, others now exist in areas previously regarded as being free of rabbit burrows. Migration from the south and west to concentration in the northern woodlands must have been given great impetus by the three major myxomatosis epidemics (Towns 1972). This has been further encouraged by more recent land management programmes undertaken to improve drainage, thin out timber and clear scrub while opening up rides and footpaths. The vegetational progression which followed the cessation of grazing by domestic beasts on the western plains (Beven 1968) continues to the disadvantage of the rabbits. Many of the larger communities now live around the 150ft contour line, somewhat higher than they did in the past (Towns 1972), despite the continuing fall in the water-table. The eastern plains have dried out and where Castell and Peterken recorded *Sphagnum* sp. (Hillman 1975) there now lies heathland of bracken *Pteridium aquilinum* and purple moor-grass *Molinia caerulea,* both plants apparently unattractive to rabbits.

In his report, Towns delineated the known warrens diagramatically on an outline map which is reproduced below (Fig. 1), and on this the approximate locations of additional areas of burrowing activity found during the present study have been superimposed. The comparison, however, is not exact because of a difference in approach. Towns stated that his warren boundaries were based *'on signs of obvious rabbit activity and by the locations of the collections of rabbit pellets which serve to mark individual and group territories',* quoting Mykytowycz (1968). I have not followed this technique. Experience gained during the present survey induced me to question whether these criteria were not being given undue weight in determining colony perimeters.

There are few places on the Commons where rabbit faeces are not to be found in small or large quantities and, among the woodland warrens where grazing opportunities are restricted, I could find no sign of attempts to demarcate frontiers in this way. Some well-frequented latrines are scattered about at sites some distance from both feeding and digging areas, and I could find no trace of surface-living communities. Unfortunately, it was not possible to carry out a study of these largely nocturnal animals' activities which might have enabled me to interpret the significance of latrines and smaller collections of droppings found

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away from the vicinity of burrows. Consequently, for lack of evidence to distinguish territorial markers from collections of pellets having no territorial significance, I have indicated on the map only those areas actually carrying burrows and, for this purpose, have ignored all other areas of known rabbit activity which I have come to regard as probably communal to all rabbits within their very variable range.

When Dr Tittensor visited the Commons in 1977 he indicated that less is certainly known about rabbit behaviour than some of the literature might suggest. For example, the animals will extend their range to an area of known good feeding, rather than try to scrape a living on a poor one; latrines are often sited with more regard to their prominent elevation than to their proximity to a particular area; there is no reliable evidence for or against the defence of feeding territories; and there is a freer interchange of individuals, adult as well as juvenile, between warrens than is generally realized. An isolated observation possibly lending support to this last suggestion was the behaviour of some rabbits I saw feeding on the edge of a large, open meadow on the Commons' boundary. Two or three animals were grazing quite close to the boundary ditch which carried a few burrows in the neighbourhood of which lay scatterings of fairly fresh pellets. On my approach through the woods the rabbits fled across some three hundred

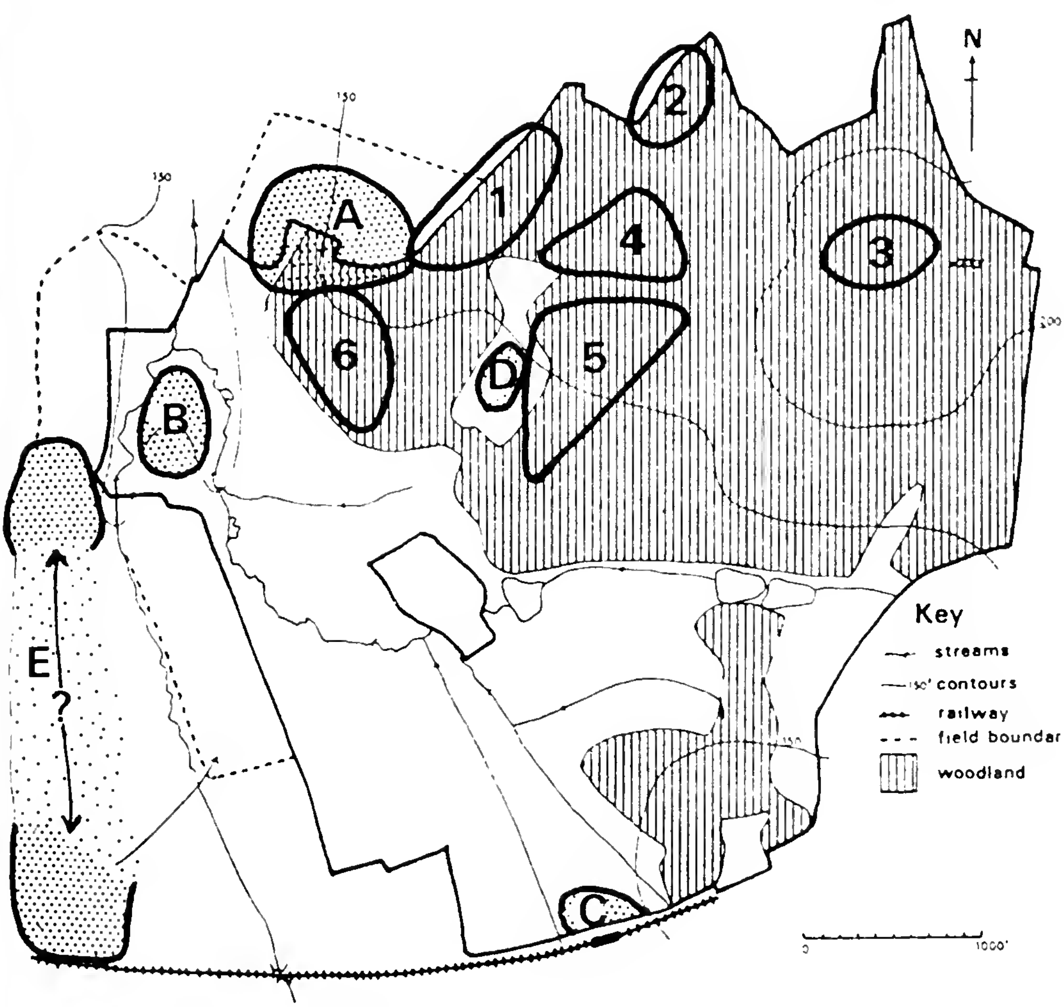

FIG. 1. Outline map of Bookham Common showing rabbit warrens. **A – E**, 1969 – 1970 Survey (Towns). **1 – 6**, 1976 – 1977 Survey (French).

yards of open pasture to disappear into the woods on the other side where the boundary ditch was also tunnelled with rabbit holes. The field grasses appeared to be similar in species all over the meadow, and the interesting, but unanswered, question arises — had the rabbits travelled some considerable distance over open ground to feed at the edge of the Commons where I saw them or had they been grazing close to home but retreated to another colony for shelter on the approach of danger?

On the outline map, Fig. 1, Towns' warrens are indicated by his letter symbols, A – E, by which he designated them in his paper; the additional 1976 – 1977 colonies are identified by the figures 1 – 6; the map references given in the text refer to the numbered squares on Castell's Bookham Common, Base Map 1942, revised in 1972 (Sandford 1975); and the botanical names are taken from Clapham, Tutin and Warburg (1962).

Report

1. The Warrens

Warren A — Hill House Wood (Squares 18/19)

Towns described this as the largest of the rabbit colonies on the Commons, and, at that time, it seems to have comprised some seventy-five burrows, distributed in sub-groups. When re-examined in 1976 scarcely a dozen rabbit-holes remained intact, mostly on the higher ground away from the farmland boundary ditch. The cause of the evacuation may have been flash-floods during the prolonged, heavy autumn rains or, perhaps, pollution from effluent draining from the farm poultry houses, turning a section of this ditch to the east, in which direction Towns' warren used to extend, into an open sewer.

Warren B — Banks' Plain (Squares 42 and 45)

Towns remarked on the remarkable spread of scrub in this area since A. W. Jones (1954) published his 'Flora', but during the past seven years the scrub has encroached even further with hawthorn *Crataegus* sp. collapsing and dying beneath climax oak *Quercus robur* and silver birch *Betula pendula,* forming dark, impenetrable thickets. Furthermore, the old grassy area which lay between the scrub and Banks' Stream is now covered in summer with dense, man-high herbage consisting mainly of meadowsweet *Filipendula almaria,* willowherb *Epilobium* sp. and stinging nettle *Urtica dioica* which the rabbits have been unable to control. Few of the grassy clearings mentioned by Towns remain among the scrub, and many of the original burrows now lie buried beneath decaying hawthorn. Rabbit-holes in use now seem to be confined chiefly to the outer ede of the scrub from which the animals continue to graze the turf among the ant-hills adjoining Five Halls.

Warren C — Station Copse (Square 88)

According to Towns (*in lit.*) this territory was always held precariously by the rabbits and, since the felling of the elms *Ulmus procera* killed by Dutch elm disease, all that remains of this small warren is half a dozen burrows dug beneath hawthorn roots at the western end of the old copse, not far from the right bank of Isle of Wight Ditch. Nevertheless, fallen tree trunks, rotting on marshy ground, are still in use as latrines, and rabbit grazing still takes place on the drier, grassy plain a little further to the north. In this area a few corpses of myxomatosis victims were found during the autumn of 1976.

Warren D — Hill House Wood (Square 51)

Towns designated this as the only area on the Commons carrying a surface-living community, but the tangle of bramble *Rubus* sp. and birch saplings which he described as the animals' habitat, has since been overtaken by mature woodland,

the old thicket no longer exists and I could find no trace of a rabbit population living there.

Warren E — Banks' Common (part Squares 48 and 72)

(According to the Ordnance Survey map, this locality might be more accurately designated Great Mornshill Wood, now part of the Banks' Farm land). As towns pointed out in his paper, this locality lies outside the confines of the Bookham Commons and, although the rabbits resident there no doubt coninue to play their part in the ecology of the study area, this survey did not extend beyond the official Commons' boundary.

No more surface-living communities have been discovered in the course of the present survey, but a number of areas now carry burrowing populations of various sizes which seem to have been unoccupied seven years ago. The division of the northern woodlands into separate warrens has often been a purely arbitrary process and made to correspond with easily recognizable, man-made boundaries. The task of defining with accuracy warren territorial limits in thick woodland carrying ground cover in varying degrees of density is extremely difficult. Breeding-stops, dug away from the main burrow concentrations initially, may be developed later into small colonies which, in turn, may be further extended in due course. I received the impression of a diffused population, concentrated in a few favoured areas, scattered in small groups elsewhere. But whether these outlying 'hamlets' should be regarded as mere 'suburbs' of larger, neighbouring communities, or be considered as separate social groupings in their own right, I have been unable to decide. It must be recognized that my artificial division of burrows into convenient groups for the purpose of this report, does not necessarily represent the natural units which may well correspond to quite different patterns.

Warren 1 — Kelsey's Wood (Squares 24/5, 27/8)

It is possible that this area became occupied by rabbits originally living in Towns' Warren A when the poultry midden referred to earlier became a noisome barrier between the two localities. The new warren has burrows running in a line below the lip of the boundary ditch on the farmland side, thirteen dug into the bank, singly and in couples, sometimes under over-hanging tree roots, stretching north-east to a point just short of Kelsey's Farm. There are in addition three or four small concentrations of up to half a dozen rabbit-holes situated further south into the woodland in the direction of Kelsey's Path.

Warren 2 — Stent's Wood (Squares 34/5)

This is a smaller edition of Warren 1 with a linear development of burrows dug into the farmland side of the boundary ditch, some seventeen in all, and spaced irregularly; in this locality, however, there is no development southward into the woods.

Warren 3 — Sheepbell Wood (Squares 37/8)

This is a small, isolated community with half a dozen burrows sunk in the angle between High Point and Sheepbell Paths, with a couple more, separated from the rest, dug into the steep bank of Sheepbell Hollow.

Warren 4 — Stent's Wood (Square 28)

Situated here is a single concentration of ten burrows at a point near the centre of the wood, with four sets of outliers having between two and six rabbit-holes each, the whole being confined within the angles made by the surrounding paths; possibly this is merely a 'suburb' of Warren 1 in Kelsey's Wood.

Warren 5 — Central Wood (Squares 52/3, 55)

This is an extremely scattered warren with no obvious cohesion and may have no significance as a natural unit. There is a concentration of a dozen burrows towards the eastern end of the wood, close to High Point Path, and two smaller groups of six, one at the junction of Woodland and High Point Paths, and the other close to Glade Path, while around the perimeter of the area are outliers in three places of two or three rabbit-holes each.

Warren 6 — Hill House Wood (Square 48)

This is certainly the most impressive new warren found on the Commons during the course of this survey. It is sited at a height not far below the 175ft contour line on a hummock on the southern side of the wooded hillside, remote from human traffic, in a glade beneath a closed canopy of Turkey oak *Quercus cerris* among scattered bramble clumps. The citadel comprises some fifty closely associated burrows with numerous outliers distributed in small groups of varying size describing a circle around the central hub, the whole being located in the triangle formed by Common Road (North), High Point Path and the un-named ride which connects them.

2. Other Areas

Signs of rabbit activity on Eastern Plain and in South-East Wood are less in evidence than they are elsewhere. It has been suggested that disturbance by dogs may be a contributory factor in discouraging rabbit colonization, but uncontrolled dogs regularly rampage through the northern woodlands where they do not appear greatly to worry the resident rabbit population which easily finds refuge in the numerous burrows. I am inclined to the view that the unattractive nature of the Plain's vegetation as fodder may be the chief deterrent. The failure of the rabbits to occupy South-East Wood despite the area of apparently suitable grass grazing on both sides of Broadway (South) with pasture fields hardby beyond the Commons' boundary, may have been due to the dense tangle of bramble and bracken groundcover which luxuriated beneath the trees. (This area, like the rest of the Commons' woodland, was carefully searched for rabbit-holes during the course of the survey, but none was found. It is interesting to note that after this survey was completed, a good deal of undergrowth clearance took place and ample signs of burrowing activity soon made their appearance).

A different situation exists on parts of the low-lying Isle of Wight and Bayfield Plains to the west, an area subjected to frequent and extensive winter flooding. Large tussocks of tufted hair-grass *Deschampsia cespitosa* stand isolated amidst erosion channels in some places and these, surprisingly, often carry latrines on top of the clumps although the grazing prospects appear to be minimal. Burrowing under these conditions is, of course, impossible, except, perhaps, in some of the scattered, drier thickets, but no sign of such activity has been found in them and a more inhospitable area for surface-living it would be difficult to imagine.

3. Effects on Vegetation

On the plains particularly, the rides and paths where grass is allowed to grow without being obliterated by horses' hooves are meticulously mown by the rabbits, but damage to shrubs and trees appears to be minimal, except in winter when hawthorn is often barked, and one report indicates that shoots of butcher's broom *Ruscus aculeatus* are occasionally taken in the woods. It is hoped that one day a systematic botanical study of the rabbits' food plants on the Commons will be undertaken, but, in this instance, it has only been possible briefly to examine a

limited area and to note a few of the plants that appear to be favoured by the animals and some of those they tend to avoid.

Plants found to be taken	Plants apparently avoided
Stellaria graminea	*Pteridium aquilinum*
Trifolium repens	*Ranunculus repens*
Potentilla erecta	*Cerastium holosteoides*
Crataegus sp.	*Potentilla anserina*
Gnaphalium uliginosum	*Polygonum persicaria*
Ruscus aculeatus	*P. hydropiper*
Juncus effusus	*Veronica serpyllifolia*
Poa annua	*Odontites verna*
Deschampsia cespitosa	*Mentha arvensis*
Agrostis sp.	*Plantago major*
	Cirsum arvense
	Sonchus asper
	Molinia caerulea
	Holcus lanatus
	Carex hirta

Hairy sedge *Carex hirta*, although not generally taken, appeared to have been cropped in one place, while lesser stitchwort *Stellaria graminea* was only grazed when other preferred food was in short supply. It was pointed out (Beven 1968) that tufted hair-grass seemed to be taken fairly freely, especially during the winter, despite suggestions to the contrary in the literature, but the avoidance by the rabbits of Yorkshire fog *Holcus lanatus* was made abundantly clear by the little islands of this grass standing untouched on wide rides where almost every other plant had been grazed to the ground. Towns has remarked (*in lit.*) that rabbits sometimes take bramble, but I have never noticed this. The wild rose *Rosa* sp. also appeared to be shunned except on a single occasion when I inspected stems of this plant which I had cut nearby as latrine markers and found to be severely barked although the plants from which they had been taken, growing in the immediate vicinity, remained undamaged.

Having considered the foregoing list of plants, B. R. Radcliffe (pers. comm.) has made the following comments on the apparent avoidance of some of them by the rabbits:-

Hairy:-	*Carex hirta, Cerastium holosteoides, Holcus lanatus, Potentilla anserina* and *Odontites verna* (which last may be toxic also).
Spiny:-	*Cirsum arvense* and *Sonchus asper* (although he remarks that pet rabbits seem to relish the second species).
Strong flavour:-	*Mentha arvensis* and *Polygonum hydropiper.*
Toxic:-	*Ranunculus repens* and *Veronica serpyllifolia* (but he comments that other plants of both genera have toxins present and he has found *V. chamaedrys* apparently taken by rabbits in winter on Epsom Downs).

Radcliffe finds it surprising that both *Plantago major* and *Polygonum persicaria* seem to be rejected while a hairy plant like *Gnaphalium uliginosum* was taken, but he suggests that the hairs of the last named plant, being short and soft, may be acceptable.

4. Dr Tittensor's Visit

Dr Tittensor's comments concerning territorial behaviour have already been mentioned, but, in the course of discussion, other points of interest arose. He was accompanied by his dog which he has trained to detect by scent the presence of rabbits in individual burrows, the animal becoming very excited at occupied rabbit-holes while showing little interest in the vacant ones. Burrows which are occupied one day are often vacant the next and, since rabbit-holes form elaborate inter-connecting systems, not all of them are in daily use and debris drifted into

burrow entrances is not evidence of abandonment. While surface-living is fairly general, this is usually a sporadic practice by individual rabbits which occurs only when circumstances make it necessary, and is not normally the settled habit of particular communities. Rabbits seen by day are probably those disturbed while lying-up above ground and sightings should not be taken as indications of surface-living nor that the animals have adopted diurnal habits. Tittensor was sceptical about the reliability of pellet-counts in assessing rabbit population levels. In his view the only dependable census method is to count the rabbits seen during regular dawn and dusk patrols over fixed routes at regular intervals, a procedure which requires experienced observers to detect the animals with certainty under twilight conditions.

Conclusions

Despite the extension of the known rabbit-occupied areas during the past seven years there appears to be no sign of an imminent population explosion. Perhaps a low-level of endemic myxomatosis coupled with natural predation and licensed ferreting are keeping numbers in check despite the fact that the Rabbit Clearance Society, which used to operate on the Commons in Towns' day, has ceased culling the animals. The impression gained during the present survey is that the Commons' rabbits like to avoid thick ground-cover at burrow sites wherever possible, perhaps because the advantages of concealment are outweighed by the danger of ambush by predators. They seem, rather, to prefer more open woodland where the soil is well-drained and hawthorn, bramble and bracken do not form dark, impenetrable thickets. Although rabbit burrows form semi-permanent features of the landscape wherever they occur, their numbers are not a good guide to population levels which fluctuate seasonally under natural conditions according to the pressures of disease, predation and human interference. I formed the opinion that, except in the special cases of bucks guarding their does, and of does protecting their breeding-stops, the rabbits' social structure was a good deal looser in many respects, and their territorial sense less rigid, than I had previously supposed.

Acknowledgments

My grateful thanks are due to the following for much help and encouragement during the survey itself and in compiling this report:- Dr G. Beven, Miss E. M. Hillman, Mr B. R. Radcliffe, Miss J. M. Stoddart and Mr M. Towns; also Mr N. Davies, National Trust Keeper and Dr E. T. C. Spooner, Honorary Commons Manager; and particularly Dr A. M. Tittensor of the Ministry of Agriculture, Fisheries and Food.

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Book Review

Umbellifers of the British Isles. By T. G. Tutin, illustrated by Ann Davies. 197 pp. Botanical Society of the British Isles, London (c/o British Museum (Natural History)). 1980. £5.00.

This booklet is numbered as 'B.S.B.I. Handbook No. 2' in succession to Jermy and Tutin's *British Sedges* (1968) on which it is closely modelled. Each of 73 species is the subject of a full-page line drawing and facing text containing a full description and somewhat sketchy habitat and distribution data. The introductory matter includes a general account of the Umbelliferae, a note on their classification and relationships, lists of the species according to habitat, a note on culinary uses, a traditional indented dichotomous key and a more novel multi-access key which is much quicker to use once one has got the hang of it. The drawings are magnificent and the descriptions are very comprehensive; criticism of these can only be of points of detail. In the former, *Smyrnium perfoliatum* lacks radical leaves. In the text, the shape of the cotyledons is not a helpful character, whatever its systematic value; who has ever seen a seedling of *Aegopodium*, for instance? If any general observation is justified it is that Prof. Tutin has underestimated the difficulty beginners experience with umbellifers; these are surely the people for whom a book with a full-page drawing of each species is intended, as the expert already has the ability to interpret the botanical descriptions in existing floras. Most pages of text have blank space at the bottom which could helpfully have been used for more extended comparisons between similar species, for magnified drawings of significant details like the 'finely serrulate' leaves of *Silaum* and the 'minutely serrulate' leaves of *Selinum*, or for notes on the variation of such species as *Apium nodiflorum*, which might go some way towards an explanation of the omissions of some presumably erroneous stations of the rare *A. repens*.

R. M. Burton

Conservation in the London Area 1979

by SUSAN JOY*

As in previous years a wide variety of sites and wildlife conservation matters within London has been brought to the attention of the London Nature Conservation Committee. Under the chairmanship of Mrs Pearl Small the Committee met five times, its members representing a wide range of interests from all parts of the conurbation. Representatives from the four Nature Conservation Trusts attended meetings as did the Nature Conservancy Council's Assistant Regional Officer for London, Mr Richard Findon. Many of the items on the LNCC agenda recur from meeting to meeting since they require constant monitoring and interest by members of the Committee; others may be dealt with quickly and efficiently by putting individuals or groups requiring assistance in touch with the right contact.

Recent discussion on the membership of the Committee has led to a small increase in the number of representatives which has made for more effective discussion and support. The question of the responsibility for the old London County Council area has been raised again and local Trusts have been asked to look closely at the current problems caused by unsatisfactory boundaries. This issue has been highlighted by the Nature Conservancy Council's current campaign to heighten public awareness of wildlife in the city. Consequently a meeting was held in December to which a large number of voluntary societies in the GLC area were invited to discuss, in particular, the ways in which local authorities could be helped when requiring advice on wildlife conservation matters. A central referral point, manned by the LNCC Secretary, has now been established, based at the Council for Environmental Conservation to which enquiries may be directed (01-722 7111).

Major problems discussed in the Herts. and Middx. area have included the management of Holland Park and the difficulties of reconciling wildlife conservation interests with the carrying out of GLC Parks Department duties. The 'Friends of Holland Park' has been established and good communication links now exist between the Group and the GLC, and the Group and LNCC. Chiswick Ait and Oliver's Island in the River Thames have given much cause for concern which is yet, in the latter's case, unresolved. However, the management of Hampstead Heath continues to improve and tree planting has been undertaken.

The main topics raised within Buckinghamshire have been in connection with the Colne Valley Committee on which the Chairman represents the LNCC. Members of the LNCC Committee welcome the proposal that the River Frays Meadows should be designated as an educational nature reserve.

Both Kent and Surrey have suffered from the damaging effects of the M 25 motorway schemes but concerted efforts have been made to protect valuable sites where possible. Evidence has been provided by members of the LNCC at the majority of public enquiries that have been held and in certain cases these representatives have shown that they have more knowledge about geological and protection status (SSSI and common land) than the Department of Transport.

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In Surrey the River Wandle has suffered from pollution from a BP discharge and members of the LNCC have been involved in stopping damage to a meadow area on National Trust property. Contributions have also been made to local and district plans on wildlife conservation matters.

In Kent the LNCC has been asked to support local groups in objecting to a road scheme which would ruin Ruxley Gravel Pits and also to request that a barrier be erected between Bourne Wood and adjacent wasteland which will be a motorbike scrambling track if planning permission is given.

Matters raised in the Essex area covered a wide range including the setting up of a Lee Valley Committee similar to the Colne Valley Committee, on which a representative of the LNCC had been asked to sit; the concern over local attempts by the Council to eradicate brown-tail moths without thought for other species and the interest shown in a geological site at Walton-on-the-Naze.

Other LNCC matters which have been discussed include the improvement and re-establishment of communication with the University of London's Extra Mural Department which runs the Diploma course in Conservation. Very often course members are willing to undertake projects on sites that the LNHS would like surveyed. The difficulty in obtaining good botany lecturers was noted and concern shown that this subject is not very often taught at 'A' level now.

The LNCC records with regret the resignation of its Chairman, Mrs Pearl Small, who has so ably occupied this position for ten years. Her knowledge of the natural history and wildlife interest of London will be sorely missed as will her enthusiasm in all its aspects, but we welcome her future attendance at meetings as Adviser to the Committee. Her successor, Mr John Montgomery, is currently Chairman of the Surrey Trust for Nature Conservation, and the Committee looks forward to continuing its work under his leadership.

Botanical Records for 1979

by R. M. BURTON*

Summary

Important botanical records from the London Natural History Society's recording area are presented. Outstanding in 1979 were in Kent *Salsola kali* and *Solidago canadensis x virgaurea;* in Surrey *Orchis morio* in quantity, *Pilularia globulifera* and *Vicia sylvatica;* in Essex *Trifolium ochroleucon* and flowering *Utricularia neglecta;* in Herts *Lathraea clandestina;* in Middlesex *Bidens frondosa* and *Rumex maritimus;* and in Bucks *Ranunculus parviflorus.*

Introduction

The year 1979 produced further abundant evidence of the London Area's potential as a hunting ground for the enterprising field botanist hopeful of making new discoveries. Few of these were made in the early part of the year when for long periods the weather was cold and unpleasant. This adversely affected the flowering of vernal species, which was much delayed, producing the odd effect of compressing the spring of the year into a few weeks in May when flowers normally to be observed separately during a period of three months could be seen simultaneously. Tulips flowered exceptionally well, including the naturalised *Tulipa sylvestris.* A colony of this species which has persisted in a grove near Harefield church (08T48) for well over a century, but has not been noticed in flower since 1887, produced two blooms in 1979.

The reference 08T48 above indicates that the locality is in the area up to 2km east of grid line 04 and up to 2km north of grid line 88 on Ordnance Survey maps. The system of dividing the area in which the London Natural History Society records, approximately a circle 64km (40 miles) across with St Paul's Cathedral at its centre, is explained by Sandford (1972).

Records

V.C. 16, West Kent

Two plants completely new to the area were discovered in 1979 and one of these, *Solidago x niederederi* Khek, is also a first British record. I found this natural hybrid of *S. canadensis* and *S. virgaurea* while employing a few spare minutes forced upon me by one of the many disruptions to the service of British Rail's Southern Region, by the footpath adjacent to the cutting containing Swanley station (56T08). A fuller account of it should have been published in *Watsonia* before the present text. The other is *Salsola kali,* which J. R. Palmer found at Greenhithe (57T84) in the course of a systematic survey of drift-line habitats along the Kent shore of the tidal Thames. There were four good-sized plants spaced over about 70m of shoreline and possibly others overlooked, as the site is also densely populated by *Atriplex hastata* of similar coloration. The prickly saltwort is common in some parts of Britain near to high-water mark on exposed sandy shores but has never previously been recorded so far up an estuary, or indeed anywhere in West Kent. Other plants revealed by Mr Palmer's survey include *Ambrosia trifida* L., *Iva xanthifolia* Nutt., *Lappula myosotis* Moench and *Xanthium echinatum* Murr., all at Greenhithe; these probably came from seed brought down by the river from the oil-milling works on the bank which in one way or another has been the likely source of all the aliens reported by him

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(1977). Mr Palmer also found *Apera spica-venti* in a number of places near the tideway (in 57T64, T66 and T84); this grass was hardly known in West Kent in recent years, but we have had several records from nearby localities in Essex. *Orobanche elatior* came from near Fawkham (56T88), the only Kent locality extant in our area, previously discovered about 12 years before by P. C. Hall but not published then, and in the same area around cornfields weeds found included *Descurainina sophia, Fumaria parviflora* and very oddly *Verbascum bombyciferum* Boiss.

Otherwise the best news we have from Kent is that the rarity *Polygala austriaca* still occurs on the steep slope above the mouth of Polhill railway tunnel (56T00), together with *P. calcarea* and *Acinos arvensis.* This was reported to me by Mrs J. Pitt, who also with friends in the Orpington Field Club continued a survey of Westerham and adjacent woods (45T44 and T24). *Paris quadrifolia* is there in two stations, one with over 100 plants, the other with twice as many. Other plants of the wood include *Carex demissa, C. paniculata, C. pseudocyperus, C. strigosa* and *Valeriana dioica.* Mrs Pitt also secured expert identifications of several aquatic *Ranunculus* from Dr N. G. Holmes. The plant in the River Cray (46T68, 57T04) is now to be called *R. penicillatus* (Dumort.) Bab., though in Dandy (1958), which is my usual nomenclatural standard, it appears as *R. aquatilis* subsp. *pseudofluitans. R. peltatus* Schrank *(R. aquatilis* subsp. *peltatus),* the commonest of these in ponds, is in Coopers School Pond, Chislehurst (46T48), but the true *R. aquatilis* is in Joydens Wood (57T00).

This wood was the object of the Society's meeting on 16th June, when we were fortunate to have the company of Dr C. West, for long the country's leading expert on hawkweeds. He was able to identify for us *Hieracium salticola, H. strumosum* and *H. trichocaulon* (47T80) and also *H. cheriense* and more *H. trichocaulon* (57T00). The last-named included a population of plants with narrower leaves and more densely glandular-hairy involucres which might merit varietal separation. Also seen were a sapling *Sorbus x thuringiaca* (47T80), a number of plants of *Vicia lathyroides* near the picnic area (57T00), the second recent locality discovered in West Kent, and colonies of both *Juncus bulbosus* and *J. kochii* F. W. Schultz by different tracks (57T00) and here appearing reasonably distinct.

Other 1979 records from West Kent are *Solanum sarrachoides* as a weed in a potato crop near Hockendon (46T88) found by Dr G. S. Joyce and confirmed as the segregate *S. nitidibaccatum* Bitter by Dr J. M. Edmonds, and *Hyoscyamus niger* on Swanscombe Marshes (57T84) found by B. Wurzell. A. Willmot found a new locality for *Serratula tinctoria* in scrub at the edge of playing fields at Mottingham (47T22) and from the same source I learnt of *Apium graveolens* in a ditch in the grounds of Eltham College (47T02) and *Sorbus torminalis* in a relict scrap of wood also at Mottingham (47T02).

V.C. 17, Surrey

Quite the most remarkable botanical discovery of 1979 in our part of what used to be Surrey is of some thousands of plants of *Orchis morio* in an area of undisturbed land (26T**) owned and managed by one of the London boroughs, where they were found by the young daughter of an officer of the borough council who realized she had chanced upon something unusual, if she did not know just what it was. Also on this site, which the proprietor has undertaken to leave as it is, are *Carex flacca, Lathyrus nissolia* and *Primula veris,* further indications of ancient grassland on the London Clay.

Our meeting of 24th June was a visit to Headley Warren, a Surrey Naturalists' Trust reserve whose flora is well known. On this occasion we assembled at Leatherhead Station (15T66) where the vegetation of a disused siding included many interesting plants, among them *Chaenorrhinum minus, Colutea arborescens* and *Hieracium trichocaulon.* On the way there I noticed a strong plant of *Filipendula vulgaris* on the west side of the railway track north of Mitcham Junction (26T88). Later in the year I went back to this area and walked round Mitcham Common with Miss P. Bartlett and other members of the Wild Flower Society and South London Botanical Institute. On the down platform of the station (26T86) *Verbena officinalis* flourishes, and the other platform has *Hieracium salticola,* determined for me by Dr West, and again later for Mrs E. Norman who also found there *Calamagrostis epigejos* and *Chrysanthemum balsamita* L., the latter as yet scarcely out of a garden but likely to spread further. This is costmary, a herb with a smell like peppermint. The *Hieracium* is also nearby on the common; this its third Surrey locality. Also on the common we were able to confirm the continued presence of *Cirsium dissectum* and *Ranunculus hederaceus* (26T86), *Genista anglica, Oenanthe lachenalii* and *Ononis spinosa* (26T88). A sterile hybrid of *Potentilla erecta* and probably *P. reptans* was found in many places; this has previously been erroneously reported as *P. anglica,* which is very similar.

The survey being conducted by members of the Croydon Natural History and Scientific Society again produced many noteworthy records. At, or rather after, one of their meetings abundant *Vicia sylvatica* was discovered on private ground on the chalk near Reigate (25T40). The only previous record from Surrey is pre-war and probably wrong anyway, and the nearest extant colony of this handsome vetch is a long way from the London Area. The habitat looks like a native one but the ground was formerly the property of C. E. Salmon, the author of a posthumously published Flora of Surrey, who died on the first day of 1930 and might have introduced it. Almost as remarkable is E. C. Wallace's discovery of *Pilularia globulifera* by the large pond on Burgh Heath (25T46); this is not even one of the many localities listed by Salmon and other old floras which no longer produce the plant. As usual it was infertile. Another extraordinary record of a typically sterile plant is the *Littorella uniflora* found by R. Clarke in a pond at Worms Heath (35T66); this pond was restored after gravel working at this site ceased a few years ago. Dr J. I. Byatt found *Silene noctiflora* as a weed in a field at Kingswood (25T44) and *Saxifraga granulata* in many new localities in and near to Croydon. This species is conspicuous in flower but has evidently been overlooked in the mown grassland of parks and cemeteries where there are only radical leaves and the bulbils by which it is spread to recognize it by. Other excellent discoveries are *Selaginella kraussiana* in Reigate parish churchyard (25T40) found by Mrs Byatt and Mr Wallace, *Chenopodium berlandieri* in a weedy field south of Bletchingley (35T20), found by Mrs Byatt and Mr Clarke, *Veronica scutellata* found by Mrs Byatt near Hurst Green (45T00) and *Nardurus maritimus* on Chapel Hill, New Addington (36T80) also found by her. This slender grass is believed to be very rare but can easily be missed. It should be searched for on bare chalky or stony ground; in the new locality it is on an ant-hill.

Amaranthus hybridus is very abundantly naturalized on a fruit farm at Hersham (16T02). It was first spotted here in September 1978 by M. J. Marshall and reported in *Wild Flower Mag.* **384** : 18 (1979). Miss E. M. Hillman, K. Page, B. R. Radcliffe and I visited the place a year later and confirmed that there are many thousands of plants all over an area exceeding 100 acres. There are few other weeds of interest on the farm but the bank of the River Mole which borders it has good populations of *Cuscuta europaea.* Miss Hillman had earlier sent me a specimen from Chipstead (25T66) of *Allium vineale* with numerous good wine-red

flowers among the usual bulbils. Another good find of hers was *Galeopsis angustifolia* at the edge of a field at Titsey (35T84).

R. J. Pankhurst saw a tree of *Amelanchier lamarckii* F. G. Schroeder on East Sheen Common (17T84). All the *Amelanchier* plants naturalized in the London Area, most of which are further out in Surrey, appear to be of this species, described by Schroeder (1968) to accommodate garden escapes in Europe wrongly referred to *A. laevis* or other North American species. Mr Pankhurst also reports *Helianthus tuberosus* L. well established among *Angelica archangelica* below Chiswick Bridge (27T06) and *Rosa pimpinellifolia* still flourishing on Barnes Common (27T24).

Ham Moor near Weybridge (06T64) used to have an interesting assortment of plants of damp grassland but is now a municipal rubbish dump, which in 1979 was visited many times by J. M. Montgomery, partly in the company of Mrs E. Koh. Some of its native plants are still present, such as *Carex vesicaria* and *Lysimachia vulgaris,* but these will certainly decrease in favour of the aliens which here include *Lupinus arboreus,* already well established, *Datura stramonium* and several commonplace garden escapes. It is hard to know in which category to put the few plants of *Filipendula vulgaris* seen here.

V.C. 18, South Essex

I am indebted to K. J. Adams for putting me in touch with a number of amateur botanists whose names have not appeared in this journal before. Of these the best discoveries in 1979 are due to B. L. Coombes. Near Stapleford Tawney (59T08) he found *Trifolium ochroleucon* in old grassland, the first reliable record of this species so near London for many years (it is more frequent further north just outside our area). Also at this locality were *Carex acuta,* abundant *Rhinanthus minor* and *Primula veris,* and the hybrid of the latter and *P. vulgaris.* In and near Holdens Wood, Warley (59T80) he had the good fortune to discover *Blechnum spicant, Cardamine amara, Chrysosplenium oppositifolium, Convallaria majalis, Hydrocotyle vulgaris* and *Scirpus setaceus.* These all appear to be native species in this locality, which has obviously been long unexplored botanically, but *Eranthis hyemalis, Lathraea clandestina,* a solitary *Osmunda regalis, Phyllitis scolopendrium* and *Pulmonaria officinalis* betray the influence on the district of Miss Ellen Willmott whose famous garden was about 500m away. The status of *Fritillaria meleagris,* discovered in old meadow land now enclosed in a garden in the same area, must remain obscure. At Navestock Side (59T66) Mr Coombes found *Polygonum bistorta* and other damp-loving plants, many of which will not survive into 1980 because of 'improvement' works being undertaken there, and in water-works land nearby *Medicago arabica* has become abundant. Horseman's Side at Navestock (59T46) produced a number of plants of *Verbena officinalis.* In Navestock Park (59T28) he found *Carex pseudocyperus, C. strigosa* and *Galium uliginosum;* this is a scheduled Site of Special Scientific Interest badly in need of thorough investigation. Finally from among Mr Coombes' many interesting records I select the plants of a roadside at Gidea Park (59T20), used for overnight parking by lorries newly arrived from the Continent, which may somehow account for the introduction of *Centaurea calcitrapa, Silybum marianum* and *Coronilla emerus* L. which has got established in the hedge.

Mrs P. S. Swettenham has been exploring the Upminster area very thoroughly, with other members of the local group of the Essex Naturalists' Trust. There are still habitats worth maintaining along the valley of the Ingrebourne and south and east of Cranham. From near the Ingrebourne north of Upminster (58T46) they produced a long list of flowering plants including *Allium ursinum, Lathyrus*

nissolia and *Rhamnus cathartica.* In November the habitat of the *Allium* was covered by dredged mud and it remains to be seen whether it will recover. The *Lathyrus* was also abundant in a meadow west of Franks (58T88) as were *Genista tinctoria* and *Silaum silaus. Silaum* reappears in another long list, from Havering Park (59T02), to which are added, on information from the park keeper, *Dactylorchis fuchsii, D. praetermissa* and a hybrid of these two 80cm tall. The list from Hobbs Hole (58T88) includes *Carex pendula, Galeopsis bifida* and a quantity of *Prunus cerasifera.* A wood on Hog Hill, Hainault (49T62), land belonging to the Area Health Authority left as a wildlife reserve, has many relics of pre-1950 tree planting, also *Malva moschata* and mistletoe *Viscum album* on lime. Mrs Swettenham found a large patch of *Montia perfoliata* in Hornchurch churchyard (58T46).

Dr Adams himself found *Hydrocotyle* and *Juncus bulbosus* in Hainault Forest (49T84). Long Shaw, Debden (49T46) turned out to be a relic of ancient woodland carpeted by *Allium ursinum.* At The Chase (59T06) he found a group of nine trees of *Populus nigra* not noticed by Milne-Redhead (1976). He has also confirmed and added to many of Mr Coombes' records.

Much activity in 1979 was concerned with a threat to turn Walthamstow Marshes (38T46 and T48) into gravel workings. A booklet entitled 'Walthamstow Marsh: our countryside under threat' was produced by the Save the Marshes Campaign, a local action group formed for the purpose of protecting this valuable site. It includes lists by B. Wurzell of Lepidoptera and plants. Among the latter, some 350 in number, are many found nowhere else so near to central London, what may be the only plant living of *Rumex x lousleyi* Kent *(R. cristatus x obtusifolius)* and other dock and willow hybrids. Writing in early February 1980, I can state that the Campaign has succeeded in its first purpose of getting the application for gravel digging rejected, but it still has work to do to ensure the permanent preservation of this surprising remnant of old wet pasture in east London.

Our meeting of 18th August visited the Purfleet locality of *Lactuca saligna* and nearby (57T48) found five plants of *Helianthus annuus* L. on the shore. These might have come from fruits thrown overboard from a ship passing up London's river, as is suggested for a similar occurrence in 1977 on the beach of an uninhabited island in the Baltic by Haeggström (1979). It is more likely that they are from spilt sunflower seed intended for processing at the oil-milling works on the Kent shore already mentioned. Among plants seen in Epping Forest later that day were an abundance of a *Juncus* on Sunshine Plain (49T28) more or less intermediate between *J. bulbosus* and *J. kochii* and the rare sight of *Utricularia neglecta* flowering freely in a small pond near the A 11 road south-west of Wake Valley Pond (49T08).

V.C. 20, Herts.

A small pond in the corner of Bayfordbury Park (31T00) is the site where C. G. Hanson discovered some 30 plants of *Lathraea clandestina,* a completely new species for our part of Hertfordshire. This was perhaps put there when Bayfordbury was the home of the John Innes Institute, but now looks quite wild.

Crassula helmsii (T.Kirk) Cockayne was found in a tiny pond at Batchworth Heath (09T62) by A. C. Jeffkins. The ducking pond at Shenley (10T80) had an excellent show of *Nymphoides peltata,* reported by L. K. Wilkingson. This handsome aquatic is introduced here, as it is in the Herts. and Middlesex Naturalists' Trust's reserve at Broad Colney (10T62) where it has increased immoderately. J. G. Dony sent me a very useful list of vascular plants from this locality, which includes *Carex x pseudoaxillaris (C. otrubae x remota).* The only

previous records of this hybrid sedge in our part of Herts are also his, from a gravel pit at Colney Heath (20T04) in 1958 (Dony 1967) and from Hook Wood, Northaw (20T60) in 1961. Dr Dony also supplied the name for *Corydalis bulbosa* seen near Loudwater (09T44) in the course of a Wild Flower Society meeting in April. Mrs M. V. Marsden says that *Philadelphus coronarius* on the causeway between two gravel pits at West Hyde (09T20) does not appear to have been planted there. J. R. Phillips kindly pointed out that the plants I mentioned last year as having been seen near Darlands Lake in Middlesex (Burton 1979b : 67) are in fact just on the Herts. side of the vice-county boundary, which runs through the lake and that *Fritillaria* has been reported there previously (Lousley 1967 : 12 and perhaps Crespigny 1877 : 120, who refers to it in a 'meadow near Totteridge Green').

In the course of our meeting of 6th August 1978, I collected a willow-herb on the disused railway line east of Rickmansworth (09T64) which was determined early in 1980 by T. D. Pennington as *Epolobium adenocaulon x montanum;* curiously our only previous record of this hybrid is also from a disused railway line, at Muswell Hill in 1961.

V.C. 21, Middlesex

For our best 1979 records from v.c. 21 we are again indebted to Mrs Marsden. She found *Rumex maritimus,* a dock recorded from Middlesex very seldom and at wide intervals, in plenty near a gravel pit at South Harefield (08T48). The pit is much frequented by anglers who appear to be connected in some way with the occurrence of the plant, the fruiting perianth of which has slender teeth giving it some of the characteristics of a bur. Anglers may also be involved in the dispersal of *Bidens* achenes. Mrs Marsden found the first plants of *B. frondosa* to be seen in Middlesex, by the Grand Union Canal near Harefield (09T40), while collecting data for a 1979 map of *B. connata* Mühl. Comparison with the map of 1978 records published, with a few accidental omissions, a year ago (Burton 1979a) suggests that it has increased in quantity slightly but not at all in range. (However Dr Dony has discovered it a long way to the north-west of our area still by the same canal, near Linslade, in v.c. 24 Bucks.). The Middlesex population of *B. frondosa* was later discovered independently by Mrs E. Norman. Other useful records due to Mrs Marsden include *Barbarea verna* in quantity on a bank near Harefield Place north gravel-pit lake (08T48) *Vicia lutea* in a filled-in chalk-pit SW of Harefield (08T48) which was once a refuse tip of some botanical interest, a single small plant of *Campanula glomerata* on the Chalk between Harefield and Springwell (09T40) in a part of Middlesex where it has not been seen for a century, *Lysimachia vulgaris* near Uxbridge golf course (border of 08T46 and T66), *Lagarosiphon major* massed in Harefield village pond (09T40), a fine stand of *Cicerbita macrophylla* in Fine Bush Lane between Ruislip and Harefield (08T68), *Vicia villosa* near Springwell Lock (09T42) and *Minuartia tenuifolia* still on the disused railway embankment near Denham (08T44).

Mrs Norman has also contributed records from the Thames shore at Hammersmith (27T28). Here *Veronica catenata* grows in quantity, together with such characteristic plants of London's river as *Angelica archangelica, Oenanthe crocata, Rorippa amphibia* and *Rumex hydrolapathum.* She also saw *Montia perfoliata* as a weed of flower beds in Brompton Square (27T68).

Similar habitats figure largely in the list of over 100 plants of London EC2 (mostly 38T20), compiled, for his own amusement initially, by Mr Montgomery, and need a close watch there if their weeds are not to disappear before they can be located and identified. Four plants of *Descurainia sophia* and several *Vicia tetrasperma* appeared in such a place in Moorfields and were eradicated. *Digitalis purpurea* was evidently introduced to Bucklersbury Square with rhododendrons.

Of more lasting interest are plants of lawns and old walls. Lawns in Finsbury Square and Finsbury Square Gardens have *Leontodon taraxacoides* and *Pimpinella saxifraga.* Walls in various places have two kinds of *Hieracium, Cynosurus cristatus,* one plant of *Phyllitis scolopendrium* and even a few *Catapodium rigidum,* not known elsewhere in Inner London.

Still in the same part of the City, I was taken by R. A. Softly, who has the appropriate permit from British Rail, to see the vegetation of disused railway tracks and platforms at Broad Street Station (38T20). Honesty *Lunaria annua* L. is well naturalized here; among other plants are *Carex ovalis, Juncus effusus* and *Poa angustifolia,* and the scrub vegetation includes *Populus tremula.* In a similar habitat at Holborn Viaduct station (38T00) I have seen a single plant of *Apium graveolens* in 1979. Back in the City, I found *Impatiens parviflora, Myosoton aquaticum* and *Ranunculus sceleratus* among the weeds in the ruin of Christchurch Greyfriars (38T20).

A large patch of *Ophioglossum vulgatum* was found in the grounds of Buckingham Palace (27T88) by Mr D. Mitchell, the head gardener there; it is remarkable that it should have gone undetected for so long. A. L. Grenfell told me of conspicuous *Reseda alba* by the A 4 near Heathrow (07T66?). *Amaranthus retroflexus* was found by E. J. Clement at Teddington (17T40). Mr Clement has also pointed out to me that the plant I reported as *Sonchus tenerrimus* Desf. (Burton 1977 : 90) was in fact a cut-leaved form of *S. oleraceus.*

V.C. 24, Bucks.

Miss D. Martin sent me specimens of *Ranunculus parviflorus* from a barley field at Rush Green (08T24). There are very few recent records of this rare weed from inland in S. E. England, and we have not before received one from the Bucks. part of our area.

Mr W. Langham found 12 to 15 plants of *Bidens connata* by the Slough spur of the Grand Union Canal near Iver station (08T40) where in 1978 there had only been two.

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Book Reviews

British Tits. By Christopher Perrins. 304 pp. Collins, London. 1979. £6.50.

The extent of the Bibliography comprising 430 references gives some idea of the research that Dr Perrins has undertaken in his search for information on the British Tits. All available information coupled with the long-term studies started by the late David Lack at Oxford and now directed by Dr Perrins are included. The book deals with seven species of Tit. These include the true Tits — Coal, Great, Blue, Crested, Marsh and Willow and the more distantly related Long-tailed Tit. Separate chapters cover each species and the remainder of the book is devoted to general topics such as ecological differences, territory, feeding, breeding, clutch sizes, population and predators, but with a tendency to concentrate on the commoner Blue and Great Tits.

I was particularly impressed by the way the author has drawn attention to the many unanswered questions relating to the lives of tits and the scope still available for both the professional and amateur in further research. With the exception of the Crested Tit, all the others are readily seen in the Society's area. Not only would I recommend this book as a 'must' for the scientifically minded ornithologist but to the amateur for the wealth of general information contained therein, although some might find the later chapters somewhat daunting.

J. D. MAGEE

Ireland's Wetlands and their Birds. By Clive Hutchinson. 201 pp. Irish Wildbird Conservancy, Dublin. 1979. £4.95.

The book brings together all the known data concerning the wetlands of Ireland since wildfowl counting began in the late 1940s. Apart from the introduction and conclusion, the book is divided into two main sections. Firstly, the wetlands themselves which are divided into six main areas and secondly, the birds comprising ducks, geese and swans, waders and other wetland species. The areas are fully described and contain details of the important species to be found in each, particularly in relation to their importance both nationally and internationally.

The section on the birds shows the distribution in Ireland and discusses it in the context of the north-west European population of each species. The information on duck numbers and distribution is presented mainly on maps but occasionally in graphs or tables. Bearing in mind that among the ducks there is a significant percentage of the north-west European population of four species, the information contained is valuable for the future in relation to any detailed policy for wetland conservation throughout the Island.

A book which will be of considerable use to anyone visiting Ireland and at a very reasonable price. Readers should not be put off by the wealth of statistics in relation to wildfowl numbers.

J. D. MAGEE

Mammals in the London Area 1979

by J. COTTON*

About the same number of mammal records have been submitted as for 1978, but with a different geographical distribution — more for Inner London, and a very strong representation from Surrey. Some of the comments made on the 1978 records have been borne out — notably the appearance of a porpoise. No information has been received about bat roosts, so identification must be based on owl pellets, etc. J. D. Hooper is publishing elsewhere his results using a bat recorder.

The Biological Records Centre at Monks Wood is in process of reorganization, so the possibilities of producing distribution maps have not yet been explored.

The nomenclature and checklist numbers follow G. B. Corbet's *The Identification of British Mammals,* Ed. 2 (1969).

INSECTIVORA

1. HEDGEHOG *Erinaceus europaeus* L.

BUCKS. Wraysbury gravel pits.
ESSEX. Goodmayes, Newbury Park, Upminster.
HERTS. London Colney, Rickmansworth.
INNER LONDON. Southwark Park.
KENT. Chislehurst, Eltham, Mottingham, Swanley.
MIDDX. Golders Green, Hampstead Heath, Harrow.
SURREY. Barnes, Epsom, Esher, Hersham, Kingston-upon-Thames, Peckham Rye, Wimbledon.

2. MOLE *Talpa europaea* L.

ESSEX. High Beech, Wanstead.
HERTS. Croxley Green, Rickmansworth.
KENT. Chislehurst, Petts Wood, St Paul's Cray.
MIDDX. Hampstead Heath, Harefield.
SURREY. Ashtead Common, Bookham Common.

3. COMMON SHREW *Sorex araneus* L.

ESSEX. Wanstead.
INNER LONDON. Soho (Wardour Street).
SURREY. Ashtead Common, Bookham Common, Mitcham Common.

4. PYGMY SHREW *Sorex minutus* L.

ESSEX. Wanstead.
SURREY. Ashtead Common, Bookham Common, Mitcham Common.

5. WATER-SHREW *Neomys fodiens* (Pennant).

SURREY. Bookham Common.

*74 Kidbrooke Grove, London SE3 0LG.

CHIROPTERA

Only hand records accepted for species. The following records are from skeletal remains or corpses.

18. NOCTULE *Nyctalus noctula* (Schreber)

ESSEX. Wanstead Park.

21. COMMON LONG-EARED BAT *Plecotus auritus* (L.)

SURREY Bookham Common.

CARNIVORA

24. FOX *Vulpes vulpes* (L.)

ESSEX. East Ham, Rainham Marsh, Stapleford Abbotts, Upminster.
HERTS. Rickmansworth.
INNER LONDON. Southwark Park.
KENT. Bromley, Chislehurst, Eltham, Pratts Bottom, Thamesmead.
MIDDX. Hampstead Heath.
SURREY. Anerley, Barn Elms, Bookham Common, Coulsdon, Esher, Kenley, Kew, Norbury, Peckham Rye, Purley, Streatham, Streatham Common, Tandridge, Wimbledon.

27. STOAT *Mustela erminea* L.

ESSEX. Passingford Bridge.

28. WEASEL *Mustela nivalis* L.

ESSEX. Rainham Marsh.
MIDDX. Pinner, Staines Reservoir.
SURREY. Beddington.

31. BADGER *Meles meles* (L.)

KENT. Keston.
SURREY. Bookham Common, Coulsdon, Esher Common, Horley, Kenley, Selsdon, Wimbledon, Woldingham.

32. OTTER *Lutra lutra* (L.)

HERTS. Cheshunt.

ARTIODACTYLA

44. FALLOW DEER *Dama dama* (L.)

ESSEX. South Weald.

45. ROE-DEER *Capreolus capreolus* (L.)

SURREY. Bookham Common.

LAGOMORPHA

53. BROWN HARE *Lepus capensis* L.

ESSEX. Hainault Forest.

55. RABBIT *Oryctolagus cuniculus* (L.)

BUCKS. Wraysbury gravel pits.
ESSEX. Hainault Forest, Rainham Marsh, Wanstead Park.

HERTS. Rickmansworth.
KENT. Dartford Heath.
MIDDX. Hampstead Heath, Poyle, Staines reservoirs, Wraysbury reservoir.
SURREY. Bookham Common, East Croydon, Kew, Mickleham, Tandridge, Wimbledon.

RODENTIA

57. GREY SQUIRREL *Sciurus carolinensis* Gmelin

ESSEX. East Ham, Epping Forest, Hainault Forest, Loughton, South Weald, Upminster.
HERTS. Chorley Wood, Croxley Green, Rickmansworth.
INNER LONDON. Regent's Park, Russell Square, Southwark Park.
KENT. Beckenham, Bromley, Chislehurst, Dartford Heath, Dulwich Woods, Eltham, Greenwich Park, Kidbrooke, Petts Wood, St Paul's Cray, West Wickham.
MIDDX. Fulham, Hampstead Heath, Queen Mary reservoir.
SURREY. Ashtead Common, Banstead, Bookham Common, Chipstead, Coulsdon, Croham Hurst, Esher Common, Kenley, Kew, Norbury, Norwood, Oxshott Heath, Purley, Reigate, Richmond Park, Streatham, Streatham Common, Tandridge, Tooting Bec, Wimbledon, Woodmansterne.

61. HARVEST-MOUSE *Micromys minutus* (Pallas)

SURREY. Bookham Common.

62. WOOD-MOUSE *Apodemus sylvaticus* (L.) (trap and other hand records only).

KENT. Dulwich Woods.
SURREY. Ashtead Common, Bookham Common, Croham Hurst, Mitcham Common, Norbury, Norwood, Streatham, Streatham Common, Tooting Bec.

62/63. *Apodemus* sp.

ESSEX. Goodmayes.
MIDDX. Hatch End, Hampstead Heath.
SURREY. Bookham Common, Streatham Common.

64. HOUSE-MOUSE *Mus musculus* L.

A few records received from members: widespread in London.

66. BROWN RAT *Rattus norvegicus* (Berkenhout)

A few records received from members: widespread in London.

67. BANK-VOLE *Clethrionomys glareolus* (Schreber)

SURREY. Ashtead Common, Bookham Common, Croham Hurst, Mitcham Common.

68. WATER-VOLE *Arvicola terrestris* (L.)

ESSEX. Hornchurch Chase, Rainham Marsh.
HERTS. Bricket Wood, Broad Colney, Croxley Green, Rickmansworth, St. Albans, Watford.
MIDDX. Harefield.

69. FIELD-VOLE *Microtus agrestis* (L.)
ESSEX. Wanstead Flats.
MIDDX. Hampstead Heath.
SURREY. Ashtead Common, Barn Elms, Bookham Common, Mitcham Common, Richmond Park.

CETACEA

86. PORPOISE *Phocoena phocoena* (L.)

INNER LONDON. River Thames at Southwark Bridge.

Book Review

An Illustrated Guide to River Phytoplankton. By Hilary Belcher and Erica Swale. 64 pp. H.M.S.O., London. 1979. £1.50.

The authors' intention in writing this companion to their 'A beginner's guide to freshwater algae' (1976) is to enable anyone interested in phytoplankton to identify the most common algae in British rivers, and to a lesser extent those in canals, broads, and lowland pools. A short introductory account is given of river ecology and of methods for the study of phytoplankton (collection, examination, counting, recording), followed by illustrations, keys, descriptions, a glossary, and three separate lists of references.

Some 109 species of the 71 genera mentioned in the guide are illustrated by line drawings of excellent quality and these will certainly tempt 'Many readers, in search of a name, . . . to look at the pictures first, . .' Though the illustrations and descriptions are not together in the text, they are readily cross-referred to by figure and page numbers given in the separate parts. The brief descriptions of the species are often accompanied by useful information on their taxonomy; these descriptions are grouped under the classes Chlorophyceae (Volvocales, Chlorococcales—including three members of the Ulotrichales, Desmidales), Xanthophyceae, Bacillariophyceae, Chrysophyceae, Cryptophyceae, Dinophyceae, Euglenophyceae and Myxophyceae. Simple generic keys precede the descriptions and are easy to follow; users should have little trouble identifying the algae to hand providing the material is living or freshly preserved. It would have made it easier if the keyed-out genera were followed by the page number of the relevant description. Also, those unfamiliar with algal taxonomy may be confused by the authors' treatment of *Ankistrodesmus, Selenastrum, Raphidonema* and *Koliella: Selenastrum* and *Ankistrodesmus* are keyed-out together only to be treated in the descriptions under the latter name, whereas, of the other two genera, only *Raphidonema* appears in the key although it is actually included under the description of *Koliella.* Details of references appearing in the text are included in a general list, with the notable exception of Huber-Pestalozzi 1941 which is given on p. 52 as a source for the detailed identification of the Chrysophyceae. The two additional lists are references to some of the more significant studies on rivers and canals in Britain and North America, though, somewhat surprisingly, no mention is made of similar studies in northern Europe.

This attractively produced guide should prove popular amongst the amateur, student and professional biologist alike, and goes some way to meet a long felt need for a relatively inexpensive, up-to-date and authoritative work on the freshwater algae of the British Isles. We look forward to seeing further guides in the series (one to benthic diatoms is planned) and believe they will go far in fostering an interest in freshwater algae both at home and abroad.

J. A. Moore
D. M. John

Obituaries

BARON CHARLES GEORGE MAURICE DE WORMS, M.A., PhD., F.R.I.C., F.L.S., F.R.E.S., M.B.O.U., 1903 – 1979

Charles de Worms died at the age of 76 following a heart attack at his home Three Oaks, Horsell, Surrey, on the 10 October 1979, after a period of deteriorating health. He was born in London on the 19 January 1903. His title descended from his great uncle, who was made an hereditary baron of the Austrian Empire in 1871. Educated at Eton and King's College, Cambridge, where he won the Drewitt Prize for Agricultural Chemistry, he went on to receive his doctorate from London University in 1934 with a thesis on orthodiphenyl ethers. Later, he worked as a research chemist in the Institute of the Royal Cancer Hospital, and from 1940 to 1944 at the Porton Experimental Station, where he was in charge of one of the chemical research laboratories.

His interest in the Lepidoptera began at an early age, and he soon became a keen and proficient collector whose enthusiasm for the subject remained with him throughout his lifetime. He had in fact only shortly before his death returned from a visit to the Channel Islands in search of some of the Guernsey specialities. He was also interested in ornithology though to a lesser degree, and in 1924 joined the British Ornithologists' Union, where he regularly attended the Union's dinners and most of the conferences.

He joined the LNHS in 1946, and in 1951 was elected Chairman of the Entomology Committee. He held that office for nine years and since then has been the Society's recorder of Lepidoptera. He was also an Honorary Member of the British Entomological and Natural History Society, a sometime Member of the Folkestone Natural History Society, a Fellow of the Royal Entomological Society, and a Member of the Suffolk Naturalists' Society for which for many years he contributed annual reports on his collecting in Suffolk.

Charles de Worms was a prolific writer of notes and articles, estimated to number several hundred, many of which appeared in the *Entomologist* and the *Entomologist's Record.* His lifelong practice of writing and publishing annual accounts of his own collecting first appeared in the former in 1930, and was later continued in the latter up until the year of his death. Among his other notable contributions were a series of papers to *The London Naturalist* on the Macrolepidoptera of the London Area, beginning with the butterflies (1950), followed by the moths (1954 – 58), with a supplement (1959 – 60) and nine biennial reviews (1961 – 78). In 1962 the Wiltshire Archaeological and Natural History Society published his *Macrolepidoptera of Wiltshire,* a definitive work of much value; and in 1979 there appeared his contribution to volume 9 of the *Moths and Butterflies of Great Britain and Ireland* of the chapters on the Notodontidae, Lymantriidae and Arctiidae. Since the war he became increasingly interested in the world fauna, and besides numerous expeditions in which he collected in most European countries, he visited Morocco, East Africa, the Congo, Malaysia, Australia, the West Indies and Canada, on each occasion publishing an account of his experiences.

Although he seems to have given little or no attention to the study of genitalic determination, he had a very good eye for species recognition based on external characters, and was frequently called upon at meetings and exhibitions to confirm on the spot identifications. As might well be expected during his many years of active collecting, he made many important finds. In 1933 he rediscovered the local deltoid *Colobochyla salicalis* D. & S. in the Kentish Weald; in 1934 he took

the first British *Eupithecia millefoliata* Rössl.; and with J. L. Messenger in 1959 in Cornwall, made the first record of another pug, *E. phoeniciata* Rambur. His capture at sugar of the exceedingly rare noctuid *Acronycta auricoma* D. & S. at Dungeness in 1933 was particularly notable, as was that of the second British *Chrysodeixis acuta* Walker at Horsell in 1955. Abroad he was among the first in Greece to find two butterflies, *Agrodiaetus coelestina* Eversmann and *A. damone* Eversmann, which were previously unknown west of the U.S.S.R. and Asiatic Turkey.

He only collected material which he had taken or reared himself, and apart from some interest in the Pyralidina he made no study of the micros. His large collection contained in 325 drawers thus consists mainly of the macrolepidoptera, is comprehensive in respect of the British species, and representative of many parts of the world as regards the rest. It is a particularly interesting assemblage as exhibiting geographical variation and is, moreover, remarkably well documented, with each specimen bearing a printed data label and the whole accompanied by a detailed numerical register. He bequeathed his collection to the Royal Scottish Museum, Edinburgh, but his *Chrysodeixis acuta, Panaxia dominula* L. ab. *decolorata* Kettlewell and halved gynandromorph of *Diaphora mendica* Clerck are in the Rothschild-Cockayne-Kettlewell collection at the British Museum (Natural History).

Charles was a very sociable and naturally hospitable man, who will be much missed by his many friends. He was unmarried, but readers will wish to extend their sympathy to his sister, his two nieces and other members of the family. We paid our last respects to him at a memorial service at St Martin-in-the-Fields, London, on the 29 November 1979, where the Rev. Anthony Harbottle, himself an entomologist, gave the address.

J. M. CHALMERS-HUNT

KENNETH CHARLES SIDE, F.R.E.S., 1907 – 1979

With the death of Ken Side in December 1979 we have lost a man who was once a mainstay of our Entomology Section. He served on the committee from 1959 until his retirement in 1969, and was chairman from 1963 till 1965. At this time he lived at Dartford where he taught handicrafts, principally woodwork. After retirement he moved to Cuxton in the Medway valley where he continued to take an active part in the affairs of the Kent Field Club, of which he and his wife Trudy were joint secretaries from 1964 to 1967. Before the move Ken and Trudy were often to be seen together at our field meetings south-east of London, he looking for Coleoptera and Hemiptera, she for cryptogams and flowering plants, both taking an active interest in the other's subject when not giving gentle and practical help to a novice in their own. Ken was a model amateur naturalist, studying his favourite beetles and bugs in the wild to the extent that it is practicable to observe them there, making copious field notes, and taking specimens for preservation and subsequent study. He published two papers on the Coleoptera of Farningham Wood in *The London Naturalist*, the first in 1961 (*L.N.* **40**) and a supplement in 1964 (*L.N.* **43**). Maidstone Museum not only has his collections, but also in its data-bank of Kent natural history, full lists of many groups that he had compiled.

Ken was a delightful man to be with on an outing, always ready to share the benefit of his experience while remaining modest and good humoured. As an instance of the last quality, we should mention that a few years before his death

he suddenly suffered the loss of one eye: he insisted that this was an advantage to him as it made adjusting the focus of his binocular microscope so much easier. To his widow Trudy we offer our sincere sympathy.

R. M. BURTON and K. H. HYATT

B. A. RICHARDS, 1907 – 1979

Barney Richards, who died suddenly on 28 December 1979, was an active member of the Ornithology Section from the 1940s until the early 1960s, when the pressure of business responsibilities forced him to reduce his LNHS activities, although his enthusiasm for birds remained undimmed until the end. In the early 1950s he was appointed Ringing Secretary and this led him to play a major part in the enquiry into the London starling roosts 1949 – 52. He was the most intrepid member of the team which clambered over buildings in and near Trafalgar Square to capture with large nets more than 3,200 starlings roosting on the ledges, so establishing that the vast majority of birds were, contrary to popular belief, London residents and not Continental visitors. I remember vividly some of his hair-raising exploits, not least when he suddenly appeared with his net above the clock of St Martin-in-the-Fields, whilst many feet below the London crowds strolled in blissful ignorance. The results of the starling enquiry were included in 1957 in *The Birds of the London Area since 1900* (ed. R. C. Homes) to which Barney also contributed as a member of the Editorial Committee. Later he was an enthusiastic and valuable member of the small team which produced the first full-length film by a local natural history society, *London's Birds* (1963). Barney was quiet and unassuming, with a kindly nature which endeared him both to his LNHS colleagues and the clients of his pharmacy in Gray's Inn Road. We are sorry to learn that his wife Hilda died in May of this year.

STANLEY CRAMP

WILLIAM SYER BRISTOWE, Sc.D., 1901 – 1979

Dr W. S. Bristowe, who died on the 11 January 1979, was one of this country's, and indeed the world's, great amateur naturalists. His first love was arachnology, especially spiders, and his many publications from 1919 till 1978 include the classic two-volume *The comity of spiders* (Ray Society 1939, 1941) and *The world of spiders* (Collins 1958), together perhaps his greatest contributions to British araneology. He was born on 1 September 1901 at Stoke d'Abernon in Surrey. His father and relations on both sides of the family were keen naturalists and from them he inherited his interest in animals and animal behaviour. To quote from his privately published autobiography, 'Spider-watching became almost an obsession from the age of five, and when I was able to read books about them at the age of nine and ten I was shocked that grown-ups could include so many false statements.'

The award of an Sc.D. by his University, Cambridge, on the publication of the *Comity* was a notable distinction to be conferred on an amateur. His natural history and other interests (combined sometimes with business) took him to such places as India, Sri Lanka, Malaya, Thailand, Sumatra, Borneo, the Seychelles, Australia, Kenya, Jan Mayen, much of mainland Europe, the Middle East, Brazil, the U.S.A., Madeira and more. He was the first person to set foot on the newly erupted island of Krakatau in 1931. He was essentially a naturalist and biologist and the delightful style and enthusiasm with which he wrote so many of

his papers and books has done much to promote the appeal of arachnology. His special interests were the biology of spiders, especially their feeding and mating habits, their capture of prey, their enemies, their dispersal, and their origin and distribution. Many of his papers are now classics and are extremely interesting to read. He was especially interested in the spider fauna of small islands, and as our late President J. E. 'Ted' Lousley said in his *Flora of the Isles of Scilly* (David and Charles 1971) when referring to the uninhabited Western Isles, 'W. S. Bristowe, who has landed on more of these islets than any other naturalist, listed these [six species of plants] from exposed islands in this group . . .'.

Dr Bristowe lectured to the LNHS on a number of occasions. He was particularly knowledgeable on London's spider fauna and together with D. C. McClintock, O. W. Richards and Maxwell Knight, initiated the survey of the natural history of Buckingham Palace Garden which was published in the *Proceedings and Transactions of the South London Entomological and Natural History Society 1963*, part II, December 1964. Bristowe's first visit to the Garden had been in May 1929 at the invitation of King George V.

In 1962 he was presented by the Duke of Edinburgh with the first of the Stamford Raffles Awards, then newly established by the Zoological Society of London in memory of Sir Stamford Raffles, who with Sir Humphry Davy, was one of that Society's founders. These awards are given annually to an amateur for distinguished contributions to zoology. Bristowe's award was more than justified. It is the writer's privilege to have known Dr Bristowe for thirty years. Every meeting revealed something fascinating about his knowledge of natural history, of his experiences in the field whether in the distant lands referred to earlier, or nearer to home on Skomer or the Isles of Scilly. His 'other' interests, to quote again from his autobiography, are summed up as follows: 'My chosen enthusiasms look somewhat strange including as they do personnel management, spiders and hunting wasps, genealogy and biography, athletics and games, the history of Thailand, small islands, antiques and Sherlock Holmes.' By patrimony he was a liveryman, and since 1965, Master of the 13th-century Worshipful Company of Armourers and Brasiers. He was also a Freeman of the City of London. In his passing we have lost a naturalist of unique charm and character.

K. H. HYATT

Statement of Affairs

	1978					
			Premises and Equipment Fund			
			(incorporating the Hindson and Castell Bequests)			
74,827			**Balance at 1 November 1978**			81,595
	55		*Add:* Investment deposit interest		34	
	118		National Savings Bank interest .		338	
	3,545		Investment income received		4,185	
	1,641		Income tax recovered		1,785	
	2,473		Profits less losses on sales of investments		(1,513)	
	7,832				4,829	
	525		*Less:* Custodian's charges		593	
7,307						4,236
82,134						85,831
539			*Less:* Grant to general account			483
81,595						85,348
			Accumulated Fund			
	(2,646)		Balance, deficit, brought forward		(3,828)	
		(1,382)	Deficit for year—general account	(1,880)		
		200	*Less:* Transfer from Life Composition account	—		
	(1,182)				(1,880)	
(3,828)						(5,708)
			Other funds			
			Life Composition account			
		200	Balance at 1 November 1978	—		
		200	*Less:* Transfer against general account deficit	—		
	—				—	
			Library cataloguing fund			
	99		Balance at 1 November 1978		99	
			Plant mapping scheme: Research and publication fund			
	212		Balance at 1 November 1978		212	
311						311
78,078						79,951
			Current liabilities			
	1,900		*London Naturalist* provision		2,100	
	1,900		*London Bird Report* provision		2,100	
3,800						4,200
£81,878						£84,151

at 31 October 1979

1978				
		Assets		
76,336		**Quoted investments** at cost (Market Value £82,527)		73,192
		Funds at bank and on deposit		
		National Westminster Bank Ltd.:		
	253	Current account	607	
	100	Deposit account	100	
	—	Investment deposit account	1,950	
	167	Investment cash — Capital	62	
	144	— Income	363	
	4,759	National Savings Bank account	7,833	
5,423				10,915
		Payment in advance		
88		Hire of hall for Symposium 1979		—
31		**Cash in Hand**		44
£81,878				£84,151

Report of the Auditors to the members of
the London Natural History Society

We have verified the above statement of affairs and attached receipts and payments account with the books and accounts of the Society and certify them to be in accordance therewith.

Knightway House,
20 Soho Square,
LONDON W1V 6QJ
16 November 1979

NORTON KEEN & CO.
Chartered Accountants.

General

1978		Payments		
686		Hire of halls, etc.		385
62		Lecturers' fees and expenses		64
350		Sectional expenses, including L.N.C.C.		322
12		Castell Research Centre		8
656		Library		425
53		Equipment repairs and renewals		93
64		Publicity		—
703		*Programme* printing costs		647
13		*Bulletin* and *Newsletter* expenses		382
		Provisions —		
	1,900	*London Naturalist* **58**	2,100	
	1,900	*London Bird Report* **43**	2,100	
3,800				4,200
920		Mailing costs (*L.N.* **57**, *L.B.R.* **42**, *Programme*, *Bulletin* and *Newsletter* — postage, envelopes, etc.)		788
177		Costs of Services (Auditors' fees, insurance, etc.)		256
370		Honoraria		405
102		Miscellaneous postage and telephone		101
80		Miscellaneous stationery		27
35		Sundries		80
		Atlas of Breeding Birds of the London Area		
	2,591	Bulk purchase, postages, expenses	181	
	1,000	Provision 1978	—	
1,591				181
£9,674				£8,364

Account

1978		Receipts		
	4,251	Subscriptions — current	4,347	
	69	arrears	8	
	72	in advance	91	
	79	entrance fees	63	
4,471				4,509
268		Donations		170
—		Tax recovered from deeds of covenant		412
32		Deposit account interest		23
	539	Transfer from Premises and Equipment Fund	483	
	170	Sale of surplus library stock	35	
709				518
		London Naturalist **57**		
	1,750	Provision 1978	1,900	
	1,705	Printing and expenses	1,910	
	45		(10)	
	13	Sale of offprints	3	
58				(7)
		London Bird Report **42**		
	1,750	Provision 1978	1,900	
	1,516	Printing and expenses	1,724	
234				176
	644	Sale of journals	424	
	71	*Less:* postages	50	
573				374
21		Subscriptions to *Bulletin*		25
		Symposium 1978		
	—	Sales of tickets, etc.	545	
	—	*Less:* Hire of halls, fees, etc.	460	
—				85
2		Sundry income		8
		Atlas of Breeding Birds of the London Area		
	1,370	Sales	165	
	554	Royalties	26	
1,924				191
1,382		Excess of payments over receipts (transferred to Accumulated Fund)		1,880
£9,674				£8,364

Book Review

The Tidal Thames. The History of a River and its Fishes. By Alwyne Wheeler. 228 pp. Routledge & Kegan Paul, London. £8.95.

Alwyne Wheeler is a zoologist working at the Natural History Museum with special responsibility for research into European fishes. His book contains a systematic and comprehensive account of the return of fishes and other wildlife to the Thames between 1967 and 1973, coupled with other information such as the social and economic history of London where this is important to the understanding of water quality of the river and its tributaries.

Members of the London Natural History Society already know of Mr Wheeler's interest in Thames fishes through his published papers. In 1957 he was invited by officers of the Society to compile an account of fishes in the London Area, and the resulting paper was published in the centenary number of *The London Naturalist*.

The first two chapters of the book set the scene, and describe the physical characteristics of the tideway. The use of water through the years and the early pollution of the Thames is adequately covered. In 1849 some 14,000 Londoners died of cholera which was contracted by drinking contaminated water drawn from the Thames. The background work and the measures taken to safeguard public health and reduce pollution are explained by the author. I found particularly interesting the account of Dr Albert Günther's work in the 1880s concerning the effect of polluted water on fish in what were probably the earliest experiments of their kind in Britain.

In chapter three the fisheries of the Thames are considered. Several pages of historical evidence are used to indicate the status of salmon in the river. Wheeler concludes that it is certain that the salmon was found commonly in the Thames at one time, but that it was especially abundant is unlikely. Readers may be sad to see confirmed in print that the widespread belief, cited by so many authors, that salmon were so numerous in the Thames that apprentices' indentures specified that they were not to be fed salmon more than once a week, was a myth. The information given about commercial fishing of smelt, eel, lampern, shad, whitebait and brown shrimp is interesting, and there is mention of the little known fishery for starfish.

The restoration of London's river and the re-establishment of its wildlife which is recorded in chapter four is a feat of unsurpassed credit, which at the time it was achieved was unique for its scale in the world.

The next chapters give information available on freshwater fishes, migratory and estuarine fishes, and marine fishes. So much valuable information is included in this part of the book that it is difficult to highlight single topics in a review. A hint of some of the mystery and challenge that the inner Thames offers for both amateur and professional scientists is given in some of Alwyne Wheeler's research findings. It may be relatively easy to explain why roach, dace and bleak grow so well in the tidal Thames compared with the non-tidal river at Reading, but why did goldfish, fairly common in the early years of Wheeler's survey, apparently disappear after 1971, and why is the sand-smelt rare in the Thames yet a dominant species in the Medway? Readers will find the chapter on marine fish fascinating, whether their interest is in the rarer species such as shark, sea-horse or trigger fish, or in the commercial species such as whiting, plaice, cod and sole. The Thames is a very important nursery ground for sole and it would have been interesting to see a mention of the Ministry of Agriculture, Fisheries and Food's findings in relation to this species. In 1970 their surveys indicated that the greatest concentration of sole eggs in English east coastal waters occurred between Gravesend and Canvey Island.

The final chapter looks at the promise for the future and considers the possible effects of developments such as new power stations and the Woolwich barrier. The author also discusses the prospects for successful salmon reintroduction and suggests the use of dock areas as suitable spawning sites for freshwater fish.

Despite the fact that the recovery of the river was not complete by the time Wheeler finished his surveys — very significant increases in fish populations have occurred following improvements to major sewage works on the tideway between 1976 and 1978 — I have nothing but praise for the book, which is a magnificent contribution to work in this field and will be of interest to specialist and non-specialist alike. It will be a necessary baseline for any biologist wanting information on fish in a tidal river. The book is the most important contribution to the study of fishes in the Thames since Yarrel's *A History of British Fishes* was published in 1836, and an inspiration to environmental workers and conservationists all over the world.

Michael J. Andrews

Instructions to Contributors

Submission of papers

Papers relevant to the natural history and archaeology of the London Area should be submitted to the editor, Mr K. H. Hyatt, Department of Zoology, British Museum (Natural History), Cromwell Road, London SW7 5BD, before the end of January if they are to be considered for publication in the same year. They should be typed, with double spacing and wide (three cm) margins, on one side of the paper. Authors must retain a duplicate copy. Papers should include at the beginning an abstract, summary or synopsis.

Text

Locality spellings should follow the latest editions of the maps published by the Ordnance Survey. Capitalization should be kept to a minimum. Common names of animals and plants must begin with lower-case initials, and scientific names must be underlined. When both common and Latin names are given there should be no brackets or commas separating them. Genus names should appear in full where first used within each paragraph. In descriptive matter numbers under 10 should be in words, except in a strictly numerical context. Dates should follow the logical sequence of day, month, year (i.e. 25 December 1971). Measurements should be in metric and follow the SI system (Système International d'Unités), with imperial equivalents in parentheses where appropriate. There should be no full point following Dr, Mr, Mrs or St. Lists should be in natural, alphabetical or numerical order.

References

Reference citation should be based on the Madison rules (in *Bull. Torrey bot. Club* **22** : 130 – 132 (1895)) except that a colon should always precede a page number. Capitalization in titles of papers in journals should be kept to a minimum. Journal titles should follow the abbreviations in the *World List of Scientific Periodicals* and be underlined. Examples are as follows:

In text:

Meadows (1970 : 80) or (Meadows 1970).

In references:

MEADOWS, B. S. 1970. Observations on the return of fishes to a polluted tributary of the River Thames 1964 – 9. *Lond. Nat.* **49** : 76 – 81.

MELLANBY, K. 1970. *Pesticides and Pollution*. Ed. 2. Collins, London.

WHITE, K. G. 1959. Dimsdale Hall moat, part II. *Trans. a. Rep. N. Staffs. Fld Club* **92** : 39 – 45.

Illustrations

Distribution maps should be submitted in the form of a Recording Map with symbols in Indian ink or Letraset. Solid dots are used to indicate contemporary or recent presence, circles for old records and crosses (not plusses) for other information, such as introduced species. Tetrad dots and circles should be 4·0 mm and tetrad crosses 5·0 mm, with a line thickness of 0·8 mm; all monad symbols should be 1·6 mm with a line thickness of 0·5 mm. The legend should be written outside the frame of the map and will be set up by the printer. The Mapping Schemes Secretary can provide Recording Maps, advice and dies for printing distribution symbols.

Line drawings should be in Indian ink on white card, larger than the printed size. Place names, etc., must be produced with stencils or Letraset. Legends should be separate as they will be set up by the printer.

Photographs should be glossy black-and-white prints, of good contrast, preferably half-plate in size.

Proofs

Galley proofs will be sent to authors for scrutiny, but only essential corrections can be made at that stage.

Reprints

Up to 25 free reprints will be supplied on request. Additional copies may be purchased if ordered when the proofs are returned.

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